The Impact of Short-Selling in Financial Markets

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A dissertation submitted in fulfilment
of the requirements for the degree of

Doctor of Philosophy

Discipline of Finance
Faculty of Business and Economics
University of Sydney

CERTIFICATE

I certify that this thesis has not already been submitted for any degree and is not being submitted as part of candidature for any other degree.

I also certify that the thesis has been written by me and that any help that I have received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

Signature of Candidate

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Steven Lecce

Acknowledgements

First and foremost, I would like to extend a special thanks to my supervisor, Andrew Lepone. His assistance, feedback and insightful comments throughout the years have been nothing short of exceptional and I greatly appreciate his efforts. His willingness to be available at any time when I needed some guidance has significantly enhanced the overall quality of this dissertation. Special thanks to Reuben Segara for providing guidance in the initial stages of choosing a topic and for his guidance throughout the years. Also thanks to Michael McKenzie and Alex Frino for their words of wisdom and help during the process. I would also like to thank Kiril Alampieski, Angelo Aspris, James Cummings, Anthony Flint, Peng He, Jennifer Kruk, George Li, Mitesh Mistry, Rizwan Rahman, Brad Wong, Jeffrey Wong, Danika Wright and Jin Young Yang for their friendship and insightful comments along the way. Their support and friendship has made the entire experience considerably more enjoyable than I could have ever imagined. Most importantly, I would like to thank my wife Laura for putting up with me during the entire process. Without her support I would not have made it.

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Preface

The work presented in this thesis is derived from three joint studies which are currently under review.

Chapter 3 has been accepted at the *International Review of Financial Analysis*:

Frino, A., S. Lecce and A. Lepone, 2011, 'Short-sale constraints and market quality: Evidence from the 2008 short-sale bans.' *forthcoming International Review of Financial Analysis*.

Chapter 4 has been accepted at the *Journal of Financial Markets*:

Lecce, S., A. Lepone, M.D. McKenzie and R. Segara, 2011, 'The impact of naked short-selling on the securities lending and equity market.' *forthcoming Journal of Financial Markets*.

Chapter 5 is currently under review with *The Financial Review*:

Lecce, S., A. Lepone and M.D. McKenzie, 2011, 'An empirical analysis of the relationship between credit default swap spreads and short-selling activity.' Working paper of the Discipline of Finance, University of Sydney.

Synopsis

This dissertation empirically examines the impact of short-selling in financial markets. Given the increasing participation of short-sellers in financial markets, this research provides empirical evidence on an increasingly important issue. Each chapter addresses a research question with scarce or conflicting prior research findings to provide evidence which can assist researchers, investors and regulators to understand and manage the impact of short-selling in financial markets.

The first issue examined is the impact of the 2008 short-selling bans on the market quality of stocks. While short-selling has long been a contentious issue, relatively little or no empirical evidence is available on the impact of short-sale restrictions on market quality. The results indicate that restrictions on short-selling lead to artificially inflated prices, indicated by positive abnormal returns. This is consistent with Miller's (1977) overvaluation theory and suggests that the bans have been effective in temporarily stabilising prices in struggling financial stocks. Market quality is reduced during the restrictions, as evidenced by wider bid-ask spreads, increased price volatility and reduced trading activity. Overall, whether the net effect of the short-selling bans is positive (higher prices versus lower market quality) is open to debate.

The second issue examined is the impact of allowing *naked* short-selling on the securities lending and equity market in a unique market setting where naked short-sales are restricted to certain securities on an approved list. The existing literature on the impact of short-selling examines changes in the rules governing either covered short-sales, or changes to short-sale constraints that affect both naked and covered short-sales. Consistent with Miller's (1977) intuition, stocks with the highest dispersion of opinions and highest short-sale constraints (higher lending fees) are the only stocks to exhibit significant and negative abnormal returns in the post event period. Allowing naked short-selling leads to slightly higher stock return volatility and a small reduction in liquidity (wider bid-ask spreads and effective spreads). Further testing reveals that the impact of naked short-selling on market quality variables is greater, both in magnitude and significance, in stocks with higher short-sale constraints. Using the Lin, Sanger and Booth (1995) spread decomposition model, the increase in bid-ask spread is attributed to an increase in the adverse selection component. This is consistent with the notion that short-sellers are likely to be informed traders.

Analysis of the securities lending market reveals that the demand for securities lending is reduced following the introduction of naked short-selling. While not providing conclusive evidence, naked short-selling appears to occur once stocks are added to the designated list of eligible stocks. Therefore the results in this chapter can be attributed (at least in part) to the introduction of naked short-sales. Overall, allowing naked short-selling impairs market quality (liquidity and volatility) but there appears to be some improvement in price efficiency and the results are largely limited to stocks with high short-sale constraints.

The third issue examined is the determinants of firm-level CDS spreads, using a new measure of the likelihood of firm default - short-selling. By examining the relationship between CDS spreads and short-selling, this chapter adds to the existing literature which examines the determinants of CDS spreads and also adds to the existing literature on the information content of short-selling. After controlling for the determinants of CDS spreads (credit ratings, firm-specific variables and macro-financial variables), the coefficient on the measures of short-selling (short-interest and utilisation) are positive and significant. These results are economically significant and robust to various controls including controlling for the supply of stock for short-selling, the use of changes in CDS spreads, cross-sectional controls for fixed effects, subgroup analysis by industry sector and credit rating categories, calculation of average regression coefficients using time-series regressions and the use of contemporaneous explanatory variables.

While results indicate that short-selling exhibits a positive relationship with CDS spreads, the question remains whether short-selling leads the CDS market or vice versa. Previous studies which examine the relationship between CDS spreads and stock markets (see *inter alia* Norden and Weber, 2009, and Forte and Pena, 2009) document that stock market returns lead CDS spread changes, suggesting price discovery occurs in the stock market more often than in the CDS market. Given short-selling occurs in the stock market, this implies that short-selling is likely to lead the CDS market. This is consistent with the notion that short-sellers are informed (see *inter alia* Boehmer, Jones and Zhang, 2008), given the majority of price discovery occurs in the stock market. Possible explanations for stock returns leading CDS spreads could be the structural difference between the markets in which the assets are traded. The structural differences could imply probable differences in the relative speed with which respective markets respond to the changes in credit conditions. For example, CDS markets for individual firms are OTC compared to stock markets which are traded through an electronic exchange.

Chapter 1: Introduction

Short-selling plays a prominent role in financial markets and has recently achieved notoriety over its part in the Global Financial Crisis. For example, according to former Chairman and CEO of Lehman Brothers, the collapse of the investment bank is partly due to short-selling, which allegedly depressed the stock price.[1] Short-selling is also responsible for briefly making car manufacturer Volkswagen the most valuable listed company in the world on 28 October, 2008. The carmaker's shares peaked at 1,005 Euros, which valued the company at 296bn Euros ($370bn; £237bn), exceeding the $343bn value of Exxon Mobil (the largest company at the time). The dramatic increase is attributable to short-sellers of Volkswagen shares desperately trying to buy them back so they could close their positions.[2]

While the role of short-selling is a current area of interest in financial markets, short-selling is not a new concept. The earliest evidence of short-selling in financial markets dates back to the 16th century in Shakespeare's play *The Merchant of Venice*, which references the activity of short-selling. The first records of actual short-selling date back to 1609 when a group of Dutch businessmen sold shares (not in their possession, promising future delivery) in the East India Company in anticipation of the incorporation of a rival firm. Over the next year the group profited as East India Company shares dropped by 12%, angering shareholders who learned of their plan.

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1 See Richard J. Fold Jr., Statement before the United States House of Representatives Committee on Oversight and Government Reform, 6 October 2008.

2 See BBC News, VW becomes world's biggest firm, 28 October 2008.

The notables spoke of an outrageous act and this led to the first real stock exchange regulations: a ban on short-selling in January of 1610. Laws to forbid short-selling were also passed in England in 1733 and in France under Napoleon in 1802.

This reflects the common belief that short-selling precedes market price declines and produces unfair speculative profits. In principle, both short-sellers and other traders can use abusive tactics to wrongfully increase their profits. Just as those traders taking long positions may, for example, misleadingly spread positive rumours about their company (e.g., the conclusion of an important deal) in order to sell their stock for a higher price, short-sellers may do so with negative information (Gruenwald, Wagner and Weber, 2010).

However, not all short-sellers are alike, and traders can use short-sales to hedge a long position in the same stock, to conduct convertible or index arbitrage, to hedge their option positions, for tax considerations and for market making or dealing activities. Advocates argue that short-selling plays a vital role in providing liquidity and enhancing price discovery in financial markets. If short-selling is prohibited, not all information will be fully reflected in stock prices. Poor price discovery, in turn, implies misallocation of capital in the economy. Hence, market inefficiency would lead to social (allocative) inefficiency. Short-selling can also enhance liquidity, i.e., make the completion of trades more likely by increasing the number of potential sellers in the market. Larger trading volumes again reduce transaction costs and, hence, tend to increase efficiency.

The evidence in Diether, Lee and Werner (2009a) indicates that short-sales are extremely prevalent, and in late 2007, approximately 40% of trading volume involves a short-seller. Given the prevalence of short-selling and the potential harm to markets, it is critical for investors, regulators, and academics to further understand the impact of short-selling in financial markets. Hence, the main objective of this dissertation is to empirically examine the impact of short-selling in financial markets.

1.1 Short-sale constraints and market quality: Evidence from the 2008 short-sale bans

The first chapter examines the impact of the 2008 short-selling bans on the market quality of stocks subject to the bans. While short-selling has long been a contentious issue, relatively little or no empirical evidence is available on the impact of short-sale constraints on market quality. Beginning on 14 September, 2008 with the bankruptcy of Lehman Brothers, the global financial crisis entered a new phase marked by the failure of prominent American and European banks. Globally, governments responded by announcing drastic rescue plans for distressed financial institutions. As the financial crisis worsened and with share prices falling sharply, financial market regulators turned to a familiar scapegoat, imposing tight new restrictions on short-selling. The restrictions commenced on September 19, 2008, with regulators in the United Kingdom banning short-selling (both covered and naked)[3] on leading financial

[3] A naked short-sale is where the participant, either proprietary or on behalf of a client, enters an order in the market and does not have in place arrangements for delivery of the securities. The other form of a short-sale, covered short-sale, differs in that arrangements are in place, at the time of sale, for delivery of the securities.

stocks. On the same day the Securities and Exchange Commission (SEC) announced a ban on the short-selling on financial stocks effective September 22, 2008 until October 9, 2008. Other markets soon followed and announced their own bans: Australia and Korea banning short-selling on all stocks; Canada, Norway, Ireland, Denmark, Russia, Pakistan and Greece banning short-selling on leading financial stocks; France, Italy, Portugal, Luxembourg, The Netherlands, Austria and Belgium banning naked short-selling on leading financial stocks; and Japan banning naked short-selling on all stocks (See Table 3-1 for details of changes worldwide).

The view of regulators is homogenous with respect to the rationale behind the restrictions. For example the Financial Services Authority (FSA) CEO Hector Sants notes that action was taken to "protect the fundamental integrity and quality of markets and to guard against further instability in the financial sector".[4] Callum McCarthy, Chairman of the FSA, notes "(T)here is a danger in a trading system which allows financial institutions to be targeted and subject to extreme short-selling pressures, because movements in equity prices can be translated into uncertainty in the minds of those who place deposits with those institutions with consequent financial stability issues. It (the short-selling ban) is designed to have a calming effect – something which the equity markets for financial firms badly need."[5] The SEC had similar concerns, noting "Recent market conditions have made us concerned that short-selling in the securities of a wider range of financial institutions may be causing sudden and excessive fluctuations of the prices of such securities in such a manner so

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4 FSA statement on short positions in financial stocks, September 18, 2008, FSA/PN/102/2008.

5 Callum McCarthy: Comments on short positions in financial stocks, September 18, 2008, FSA/PN/103/2008.

as to threaten fair and orderly markets".[6] Overall the comments of regulators suggest that the bans are intended to maintain fair and orderly markets by preventing speculators from placing excessive downward pressure on troubled financial firms.

The purpose of the first chapter is to empirically examine the impact of the 2008 short-selling bans on the market quality of stocks subject to the bans. Thus, in doing so the chapter also examines whether the short-selling bans achieved their desired outcome. Data from 14 equity markets around the world is employed to examine market quality in terms of abnormal returns, stock price volatility, bid-ask spreads and trading volume. To control for market-wide factors or different shocks affecting the market, banned stocks are compared to a group of non-banned stocks. Statistics for similar stocks in markets where short-selling restrictions were not imposed are also examined. The 2008 short-sale bans provide an ideal setting for these tests because it provides a binding constraint. Thus, it is not necessary to rely on proxies for short-sale constraints, as in previous research.[7] The previous research emanates from Miller (1977), who developed a model that details how short-sale constrained securities become overpriced because pessimists are restricted from acting on their beliefs. In this scenario, stock prices reflect the beliefs of only optimistic investors. Consistent with Miller's (1977) hypothesis, the empirical evidence which utilises proxies of short-sale constraints uniformly indicates that implementing short-sale constraints leads to overvaluation (see *inter alia* Chang, Chang and Yu, 2007).

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6 SEC RELEASE NO. 34-58592 / September 18, 2008.

7 Examples of proxies include Figlewski (1981) and Senchack and Starks (1990), who use changes in short interest, Chen, Hong and Stein (2002), who employ declines in breadth of ownership, Danielsen and Sorescu (2001), who utilise option introductions, Ofek and Richardson (2003), who use stock option lockups, Jones and Lamont (2002), who employ the cost of short-selling and Haruvy and Noussair (2006), who use experimental markets.

The relationship between short-sales and stock return volatility is a contentious issue and has received limited academic attention. Ho (1996) documents that the daily volatility of stock returns increases when short-sale constraints are imposed. Chang, Chang and Yu (2007), however, using a direct measure of short-sale constraints, find the volatility of stock returns increases when the constraints are lifted.[8] Consistently, Henry and McKenzie (2006) find that the Hong Kong market exhibits greater volatility following a period of short-selling and that volatility asymmetry is exacerbated by short-selling. Alexander and Peterson (2008) and Diether, Lee and Werner (2009b) both examine the removal of price tests (short-sale constraint) and observe insignificant or weak increases in daily and intraday return volatility.

Evidence on short-sale constraints and liquidity is relatively unexplored. Alexander and Peterson (2008) and Diether, Lee and Werner (2009b) are the only exceptions, and find that short-sale constraints have a limited effect on market liquidity. A reduction in constraints increases short-sale activity, but both find that the restriction results in only slightly wider spreads. The first chapter adds to the limited evidence of the impact of short-sale constraints on liquidity, in addition to examining the impact of short-sale constraints on returns and volatility.

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[8] Ho (1996) utilises an event where the Stock Exchange of Singapore suspended trading for three days from December 2, 1985 to December 4, 1985. When trading was resumed on December 5, 1985, contracts could only be executed on an immediate delivery basis (i.e., delivery and settlement within 24 hours) which implies that short-selling was severely restricted.

1.2 The impact of naked short-selling on the securities lending and equity market

While the first chapter examines the impact of short-sale constraints via the 2008 short-sale bans, the second chapter examines the impact of allowing naked short-selling on the securities lending and equity market in a unique market setting where naked short-sales are restricted to certain securities on an approved list. This opportunity is provided by a unique feature of the Australian Securities Exchange (ASX) which allows naked short-sales for certain securities on an approved short-sale list that is revised over time.

The impact of naked short-selling in financial markets is a controversial issue which has concerned regulators in recent times. In an effort to stop unlawful stock price manipulation, on July 9, 2008, the Securities and Exchange Commission (SEC) announced an emergency order to immediately curb naked short-selling on 19 financial firms.[9] On September 19, 2008, regulators in the United Kingdom also acted by banning short-selling (both covered and naked) on leading financial stocks. The SEC subsequently moved to ban short-selling on financial stocks from September 22, 2008 until October 9, 2008. Other markets soon followed and announced their own bans: Australia temporarily banned all forms of short-selling and later placed an indefinite ban on naked short-selling; Germany, Ireland, Canada, Indonesia and Greece banned short-selling on leading financial stocks; Korea banned short-selling on all stocks; France, Italy, Portugal, Luxembourg, The Netherlands and Belgium

[9] The emergency order took effect on July 21, 2008 and ended August 12, 2008.

banned naked short-selling on leading financial stocks; and Japan and Switzerland banned naked short-selling on all stocks.

Although short-selling has long been a contentious issue (see Chancellor, 2001), this latest series of bans on short-selling serves to highlight a common concern among market participants over the use of short-selling and, in particular, naked short-selling. It is interesting to note that while most markets have reinstated covered short-selling as a legitimate trading activity, naked short-selling remains largely outlawed.[10] This is an interesting development as, despite the apparent assumption that naked short-selling is detrimental, relatively little or no empirical evidence is available on the impact that naked short-selling has on financial markets.

The existing literature examines changes in the rules governing either covered short-sales (see Chang, Chang and Yu, 2007), or changes to short-sale constraints that affect both naked and covered short-sales (see Boehme, Danielsen and Sorescu, 2006). The purpose of the second chapter is to bridge this gap in the literature by directly examining the impact of allowing *naked* short-selling on returns, volatility and liquidity. This opportunity is provided by a unique feature of the Australian Securities Exchange (ASX) which allows naked short-sales for certain securities on an approved

[10] Naked short-sales are not permitted on any stocks in Australia, Japan, Hong Kong, China, Switzerland, Spain, Russia, Luxembourg and Korea. Naked short-sales are not permitted on certain financial stocks in the Netherlands, Portugal, Italy and France. In the United States, naked short-sales are restricted by requiring that sellers deliver securities by the settlement date. If violated, the broker-dealer acting on the short-seller's behalf will be prohibited from further short-sales (for all customers) in the same security unless the shares are not only located but also pre-borrowed (www.sec.gov).

short-sale list that is revised over time.[11] The addition of a security to the designated list of eligible stocks represents a shift from *only* allowing covered short-sales to allowing *both* covered and naked short-sales, thus allowing an isolation of the impact of allowing naked short-sales on financial markets.

This shift to naked short-selling may circumvent the fee charged by the stock lender, which represents a significant cost associated with covered short-selling.[12] In addition to this direct cost, there are several risks associated with covered short-selling, including the risk of a short squeeze due to an involuntarily closure of the stock loan (the short-seller is unable to find an alternative supply of stock in the event that the loan is closed). Further, naked short-selling circumvents search costs associated with locating and negotiating securities for lending. Together, these costs and risks represent a short-sale constraint which could be removed when naked short-sales are permitted.

The existing literature on short-sale constraints typically focuses on the effect of such restrictions on asset prices and volatility. Naked short-sale constraints could affect the mix of passive and active strategies of short-sellers, which could in turn affect liquidity measures such as bid-ask spreads and order-depth. As mentioned above, there is little empirical or theoretical evidence on how short-sale constraints affect liquidity. Alexander and Peterson (2008) and Diether, Lee and Werner (2009b) are the

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11 Securities are added or removed from the list based on market capitalisation, shares issued and liquidity. See Section 4.3.1 for further detail.

12 Naked short-sellers at the time of sale have not borrowed or entered into an agreement to borrow the stock and may repurchase the stock without incurring the borrowing fee. The Australian Securities Lending Association Limited estimate that these costs can range between 25 and 400 basis points, representing a significant barrier to covered short-sales. See Section 4.3.1 for further detail.

only exceptions, and examine the impact of short-sale price tests on market liquidity. The second chapter adds to the limited evidence of the impact of short-sale constraints on liquidity, in addition to examining the impact of naked short-selling on returns and volatility.

Differences between the behaviour of naked and covered short-sellers may lead to the impact of allowing naked short-sales on returns and volatility to differ from that of covered short-sales. While not academically documented, naked short-sales are often associated with market manipulation.[13] To the extent that naked short-sellers may engage in the downward manipulation of stock prices, one could expect their trades to increase stock price volatility. However, the possible shorter-term strategy of naked short-selling compared to covered short-selling may result in changes to volatility at the intraday level, rather than daily.[14] Volatility measured over shorter periods, such as 15-minute intervals and trade-by-trade based measures, contain less fundamental news and are more reflective of transitory price changes due to market structure differences or order imbalances (Bennett and Wei, 2006). Subsequently, the second chapter examines the relationship between naked short-sale constraints and volatility using daily, intraday and trade-by-trade based volatility measures.

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[13] Naked short-selling is often associated with market manipulation in the financial press. Examples include articles published in the *Wall Street Journal* and *Financial Times* (see Crittenden and Scannell, 2009 and Shapiro, 2008).

[14] See Section 4.3.2 for explanation of possible strategies of naked and covered short-sellers.

1.3 An empirical analysis of the relationship between credit default swap spreads and short-selling activity

With the onset of the financial crisis in 2007, credit default swaps (CDS) made the transition from being an esoteric financial instrument to appearing on the front page of mainstream newspapers. This increase in public awareness resulted from their implication in a series of high-profile company failures, most notably that of the American Insurance Group, AIG, which posted a record loss of US$61.7bn in the fourth quarter of 2008. In its simplest form, a CDS is a privately negotiated contract that insures the holder against any losses in the event that the issuer of a bond defaults on their payment obligations. The holder makes a periodic payment in return for this service, called the spread. The spread is conceptually similar to the premium charged by an insurance company and compensates the issuer for the risk they incur in providing the guarantee (the losses incurred during the current financial crisis tend to suggest that CDSs were significantly underpriced relative to their true risk).

Academia has a long-standing interest in the burgeoning CDS market and a substantial body of work has developed which focuses on credit-sensitive instruments. This literature is broadly categorised based on two theoretical approaches to pricing corporate bonds and credit spreads. Reduced-form models, developed by Litterman and Iben (1991), Jarrow and Turnbull (1995) and Jarrow, Landow and Turnbull (1997), use market data to recover the parameters needed to value credit-sensitive claims. Empirical applications of reduced-form models include Duffie (1999) and Duffie, Pedersen and Singleton (2003).

The second approach, developed by Black and Scholes (1973) and Merton (1974), uses structural models to connect the price of credit-sensitive instruments directly to the economic determinants of financial distress and loss, given default. Structural models imply that the main determinants of the likelihood and severity of default are financial leverage, volatility, and the risk-free term structure. Collin-Dufresne, Goldstein and Martin (2001) use the structural approach to identify the theoretical determinants of corporate bond credit spreads. These variables are then used as explanatory variables in regressions for changes in corporate credit spreads, rather than inputs to a particular structural model. Collin-Dufresne, Goldstein and Martin (2001) find that the explanatory power of the theoretical variables is modest, and that a significant part of the residuals is driven by a common systematic factor that is not captured by the theoretical variables. Campbell and Taksler (2003) extend this analysis using regressions for levels of the corporate bond spread, rather than changes in corporate credit spreads. They show that firm-specific equity volatility is an important determinant of credit spreads, and that the economic effects of volatility are large. Cremers, Driessen, Maenhout and Weinbaum (2008) confirm and extend this analysis by showing that option-based volatility contains increased explanatory power that is different from historical volatility.

This previous literature focuses on corporate bond spreads, i.e., the difference between the corporate bond yield and the risk free rate. More recent studies, however (see Benkert, 2004, Greatrex, 2009, Ericsson, Jacobs and Oviedo, 2009, and Zhang, Zhou and Zhu, 2009), focus on the relationship between CDS spreads and key variables suggested by economic theory. Thus, while the main focus of these more recent papers remains on credit risk, an important distinction is the use of CDS spreads rather than corporate bond spreads as the variable of interest.

Ericsson, Jacobs and Oviedo (2009) advocate the use CDS spreads in preference to bond spreads for a number of reasons. While economically comparable to bond spreads, CDS spreads do not require the specification of a benchmark risk-free yield curve, as they are already quoted as spreads. This avoids undue noise which may arise from the use of a misspecified model of the risk-free yield curve. The choice of the risk-free yield curve includes the choice of a reference risk-free asset, which can be problematic (see Houweling and Vorst, 2005), but also the choice of a framework to remove coupon effects.

CDS spreads could reflect changes in credit risk more accurately and quickly than corporate bond yield spreads. Blanco, Brennan and Marsh (2003) show that a change in the credit quality of the underlying entity is more likely to be reflected in the CDS spread before the bond yield spread. This could be due to important non-default components in bond spreads that obscure the impact of changes in credit quality. Longstaff, Mithal and Neis (2005) document the existence of an illiquidity component in bond yield spreads. Related to this, trading in CDS markets has increased, while many corporate bonds are rarely traded. Partly as a result, CDS data is collected at a daily frequency, while many studies that use corporate bonds typically use observations at a monthly frequency; the greater sampling frequency should allow for cleaner tests.

The aim of the third chapter is to extend the literature that empirically investigates the determinants of CDS prices. The previous literature in this area uses a range of theoretical determinants of default risk to model CDS spreads. Benkert (2004), Greatrex (2009) and Ericsson, Jacobs and Oviedo (2009) document that individual firm CDS prices are related to risk-free interest rates, share prices, equity volatility, bond ratings and firm leverage. These studies suggest that theoretical determinants of default risk explain a significant amount of variation in CDS prices. Other studies incorporate new determinants to better explain the variation in CDS spreads. Zhang, Zhou and Zhu (2009) use theoretical determinants along with volatility and jump risk of individual firms from high-frequency equity prices to explain variation in CDS spreads. Cao, Yu and Zhong (2010) find that individual firms put option-implied volatility is superior to historical volatility in explaining variation in CDS spreads. Tang and Yan (2007) find that measures of CDS liquidity are significant in explaining variation in CDS spreads.

The third chapter extends this work by proposing a new measure of the likelihood of firm default - short-selling. Diamond and Verrecchia (1987) suggest that, since short-sellers do not have the use of sale proceeds, market participants never short-sell for liquidity reasons, which *ceteris paribus* implies relatively few uninformed short-sellers. Empirical studies confirm heavily shorted stocks underperform, implying short-sellers are informed (see *inter alia* Desai, Ramesh, Thiagarajan and Balachandran, 2002, Jones and Lamont, 2002, Boehme, Danielson and Sorescu, 2006, Boehmer, Jones and Zhang, 2008 and Diether Lee and Werner, 2009a). Therefore short-sellers are informed traders who take positions by selling a company's stock in the expectation that prices will fall in the near future following the revelation of bad news specific to that firm. As such, the level of short-selling is a direct measure of the prospects for a company. High (low) short-selling indicates a more (less) pessimistic view of a company and an increased (decreased) likelihood of default. Therefore, CDS spreads should exhibit a positive and significant relationship to the level of short-selling. By examining the relationship between CDS spreads and short-selling, this chapter adds to the existing literature which examines the determinants of CDS spreads and also adds to the existing literature on the information content of short-selling.

1.4 Summary

The three chapters in this dissertation provide evidence regarding the impact of short-selling in financial markets. This chapter motivates each issue by illustrating the importance of this evidence to both academics and regulators faced with a litany of inconclusive literature in an area of ever growing importance.

The remainder of this dissertation is organised as follows. Chapter 2 provides a review of prior literature regarding short-selling in equities markets and CDS markets. Chapters 3, 4 and 5 examine the three issues discussed in this chapter. Each chapter contains sections describing the data and sample, research design, empirical results, additional tests and conclusions reached. Chapter 6 concludes by highlighting how the evidence presented in this dissertation can be used by academics and regulators in assessing the impact of short-selling in financial markets and assist in making informed decisions regarding the regulation of short-selling in financial markets.

Chapter 2: Literature review

The main objective of this dissertation is to empirically examine the impact of short-selling in financial markets. Chapters 3 and 4 of this dissertation examine the impact of short-selling in equities markets, while Chapter 5 examines the relationship between equity market short-selling and CDS spreads. This chapter reviews the literature regarding short-selling in equities markets and CDS markets. Previous literature that examines equity markets provides inconsistent evidence regarding the impact of covered short-sales on market quality, while evidence regarding the impact of naked short-sales on market quality is effectively non-existent. There is no previous literature examining the relationship between CDS spreads and short-selling in equities markets. A review of the literature concerning these issues is provided in this chapter.

Section 2.1 provides a basic description of short-selling, including the origins of short-selling and a review of the literature examining the motivations for short-selling. Section 2.2 focuses on literature concerned with examining the pricing implications of short-sale constraints in equity markets. Section 2.3 reviews the literature regarding the impact of short-selling on equity market quality. Section 2.4 evaluates literature relating to the CDS market.

2.1 Short-selling: Description and motivations

To understand the literature on short-selling this section provides a basic description of short-selling, including the origins of short-selling, different forms of short-selling and basic motivations for short-selling.

2.1.1 Origins of short-selling

While the role of short-selling is a current area of interest in financial markets, short-selling is not a new concept. The earliest evidence of short-selling in financial markets dates back to the 16th century in a reference to short-selling in Shakespeare's play *The Merchant of Venice*. The first records of actual short-selling date back to 1609 when a group of Dutch businessmen sold shares (not in their possession, promising future delivery) in the East India Company in anticipation of the incorporation of a rival firm. Over the next year the group profited as East India Company shares dropped by 12%, angering shareholders who learned of their plan. The notables spoke of an outrageous act and this led to the first real stock exchange regulations: a ban on short-selling in January of 1610. This reflects the common belief that short-selling precedes market price declines and produces unfair speculative profits. Laws to forbid short-selling were also passed in England in 1733 and in France under Napoleon in 1802.

2.1.2 Types of short-selling

The terms 'short-selling' or 'shorting' are used to describe the process of selling financial instruments that the seller does not actually own. If the value of the instrument declines, the short-seller can repurchase the instrument at a lower price. The two basic types of short-selling are 'covered' and 'naked'. In most markets, when a covered short-sale occurs, the trader borrows securities from a securities lender and enters into an agreement to return them on demand. The trader then sells the stock and delivers the shares to a buyer on settlement. While the position is open, the lender requires a cash collateral and no separate fee is payable for the loan.[15] This collateral (usually the proceeds from the sale) earns interest payable to the borrower at less than a normal market rate (rebate rate). The spread between the normal market rate and the rebate rate is the 'lending fee' which the lender earns and the borrower pays. When closing a position the trader buys back equivalent shares in the market and returns them to the stock lender. The collateral is then returned to the borrower plus interest earned at the rebate rate. There is no set time frame on how long a covered short position can be held, provided the lender does not recall the stock and the trader can meet the margin requirements.

When conducting a naked short-sale, the trader must either buy back the stock within a short time frame (usually on the same day), or arrange to borrow the stock before settlement. If the stock is bought back on the same day then naked short-sellers can avoid the cost of borrowing the stock ('lending fee') which is incurred by covered

15 Collateral is commonly in the form of cash but may also be in the form of securities or occasionally irrevocable standby letters of credit.

short-sellers. When this occurs the traders' broker will 'net off' the sell and buy order in the same stock and the trader will only pay/receive the difference upon settlement. However if the naked short-seller does not buy back the stock on the same trading day they must borrow the stock and deposit the sale proceeds as collateral, thus incurring a lending fee. If the trader does not meet settlement they will have 'failed to deliver' and may incur fail fees. Despite the widespread criticism, not all naked short-selling is abusive. Naked short-selling is often used for intraday trading, where the position is opened and then closed at some point later in the day. Also, if a market-maker does not have a sufficient supply of a particular share to meet client demand then the market-maker may employ naked short-selling to meet that demand. Some naked short-selling occurs unintentionally when a short-seller locates shares to borrow (or has reasonable belief that shares can be located and borrowed), but subsequently is unable to borrow the stock in time for delivery.

There are generally three groups of participants in the short-sale process. The groups are securities lenders, securities borrowers (short-sellers), and agent intermediaries. Securities lenders are large institutions typically including mutual funds, insurance companies, pension funds and endowments. Securities borrowers are institutions that engage in short-selling and typically include hedge funds, mutual funds, ETF counterparties and option market-makers. Agent intermediaries are institutions that facilitate the lending and borrowing of securities and may include custodian banks, broker-dealers and prime brokers.

2.1.3 Motivations for short-selling

While there are many reasons for short-selling, the 'speculative motive' associated with expected decreases in a stock's market value receives the most notoriety. A New York Stock Exchange survey, requested by the Securities and Exchange Commission in 1947, indicates that short positions established with a speculative motive comprise about two-thirds of the total short-interest of members and non-members.[16] Other non-speculative based reasons can include hedging and arbitrage activities, tax considerations and short-selling by market-makers and dealers. Similarly, Diether, Lee and Werner (2009a) highlight that not all short-sellers are alike, and traders can use short-sales to hedge a long position in the same stock, to conduct convertible or index arbitrage, to hedge their option positions, etc.

'Shorting against the box' occurs when investors take a short position in a security that they already hold long. Shorting against the box is a strategy commonly used to defer taxable gains (Brent, Morse and Stice, 1990). This allows an investor to lock in a profit and importantly delay the recognition of a capital gain (or to defer capital losses). Brent, Morse and Stice (1990), using short-interest for all securities on the NYSE from 1974-1986, attempt to explain the level and changes in short-interest and in doing so examine the motivations for short-selling. Brent, Morse and Stice (1990) hypothesise that shorting against the box should be most prevalent around the turn-of-the-year for high-variance stocks that have experienced capital gains over the previous year. Their results show that partitioning the firms based on residual variance, beta,

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[16] Short-interest is the number of shares of a stock borrowed for sale and not yet replaced.

and the existence of capital gains or losses did not explain the degree of drop in short-interest in January. Therefore, the seasonal pattern of short-interest is only weakly consistent with the use of short-selling to delay taxes.

However, after 1997, the Taxpayer Relief Act (TRA97) in the United States eliminated the opportunity to defer capital gains taxes using option strategies like shorting against the box (Arnold, Butler, Crack and Zhang, 2005). Arnold, Butler, Crack and Zhang (2005) examine the determinants of short-interest and demonstrate that, prior to TRA97, short-selling against the box was a popular trading strategy. Kot (2007) tests several explanations for short-selling using a sample of the NYSE and Nasdaq stocks during the 1988-2002 period. Consistent with Arnold, Butler, Crack and Zhang (2005), he finds that short-selling for tax reasons is present prior to the Taxpayer Relief Act of 1997, but disappears with the introduction of the legislation.

Short-selling is also an important function in arbitrage and hedging strategies. By simultaneously taking a long and a short position, market participants can hold a position in the marketplace and lock in profits without further risk from unfavourable asset price movements. Short-selling can also be used to exploit profitable arbitrage opportunities in the market. This trading strategy typically involves some form of pairs trading whereby the relative price of highly correlated assets has diverged from equilibrium (long/short hedge funds typically employ this type of strategy). By buying the stock whose price has gone down and shorting the stock whose price has gone up, profits can be made when the spread converges back to its long run equilibrium. While shorting the box in its own right cannot yield any profits, in the presence of a second asset whose value is linked to the cash market, opportunities for arbitrage profits exist. The most obvious candidates for this are futures, options or, if the stocks are sufficiently large, market index derivatives themselves. An investor might short to arbitrage a price differential between the stock and convertible securities of the stock or short an acquirer's stock from a merger and acquisition announcement (Kot, 2007).

Derivative issuers and stock options market-makers may also short-sell to hedge their price risk, in which case their net positions are market neutral. For example, when a put is purchased from an options market-maker he will normally hedge by shorting the stock, and possibly buying a call to turn the position into a reverse conversion arbitrage. Figlewski and Webb (1993) suggest that the put buyer's desire to sell the stock is transformed through the options market into an actual short-sale by a market professional who faces the lowest cost and fewest constraints.

Brent, Morse and Stice (1990) investigate arbitrage opportunities, through the existence of options and other securities, as an explanation of short interest. Investors may employ options jointly with short-sales and other securities to achieve arbitrage positions. The cross-sectional results indicate that firms with listed options and convertible securities tend to have more shares held short. The significance of these variables is consistent with short-selling for hedging and arbitrage reasons. Figlewski and Webb (1993) document a positive relationship between the existence of options and the average level of short interest, due to the hedging activities of options market-makers and professional traders. Kot (2007) also finds evidence to suggest that short-selling activity is positively related to dummy variables for convertible debt, option listing, and merger and acquisition activity on the NYSE and Nasdaq.

The above studies demonstrate that short-selling can be employed for a variety of reasons other than speculation. While these studies demonstrate the existence of short-selling for various motivations, there is a growing body of literature which examines the relationship between short-selling and stock returns. These studies attempt to examine the speculative motive for short-selling and aim to identify not only whether short-sellers are speculators, but also whether short-sellers are informed. Section 2.2.3 surveys the literature which examines the relationship between short-selling and stock returns, and, in turn, whether short-sellers are informed.

2.2 Pricing implications of short-selling

Asset pricing models usually assume unrestricted short-sales with full use of the proceeds. Most traders, however, face some type of short-sale constraint. Examples of short-sale constraints (besides margin requirements and the associated costs) include unavailability of sale proceeds, pass-through of any dividends, the up-tick rule on organised exchanges, an insufficient pool of shares to borrow, forced covering of a short position and legal or contractual prohibitions (Senchack and Starks, 1993). Recognising these constraints, an extensive body of theoretical and empirical literature has developed with regard to information arrival and asset trading models that contain the effect of costly short-selling on an asset's equilibrium price. Testable implications derived from the existing theoretical models have led to the development of empirical research on the effects of short-selling restrictions. This section reviews the theoretical and empirical literature on the impact of short-sale constraints on asset pricing.

2.2.1 *Theoretical predictions*

A large literature explores the theoretical link between short-sale constraints and asset prices. This literature emanates from the seminal work of Miller (1977), who develops a model detailing how short-sale constrained securities become overpriced because pessimists are restricted from acting on their beliefs. In this scenario, stock prices reflect the beliefs of only optimistic investors. Miller's theory is driven by short-sale constraints and the heterogeneous beliefs among investors. Given heterogeneous beliefs and no short-sale constraints, pessimistic investors can short the stock, which counteracts optimistic investors who buy long, and they jointly set equilibrium stock prices and, as a consequence, subsequent returns. However, under short-sale constraints, pessimistic investors are unable to short the stock freely, and the equilibrium price will reflect a positive bias and subsequent returns will be low. For any given level of short-sale constraint, the more heterogeneous the expectations, the greater will be the price and return bias. Likewise, given the amount of divergence in expectations, the greater the constraint on short-sales, the greater the price and return bias. In essence, binding short-sale constraints inhibit the incorporation of negative information in prices. As there is no barrier to going long, positive information is not withheld.

Jarrow (1980) is one of the first to extend the work of Miller (1977) by arguing that the impact of short-sale constraints depends on the beliefs of investors about the covariance matrix of future prices. Jarrow (1980) argues that asset prices may rise or fall with short-sale constraints depending on the belief of investors. Figlewski (1981), on the other hand, concurs with Miller (1977), arguing that when investors with unfavourable information are constrained from selling short, excess demand exists and equilibrium prices exceed the market-clearing price they would obtain if short-sale constraints did not exist. Chen, Hong and Stein (2002) directly model Miller's (1977) idea (allowing for risk aversion) and find stocks with short-sale constraints reflect optimistic beliefs and thus realise lower future returns. Duffie, Garleanu and Pedersen (2002) present a dynamic model to show that the prospect of lending fees (short-sale constraint) may push the initial price of a stock above even the most optimistic buyer's valuation.

The Miller (1977) theory implicitly assumes that investors do not obtain information from market prices. Diamond and Verrechia (1987) provide an alternative view by modelling the effects of short-sale constraints in a rational expectations framework. An important implication of this model is that short-sale constraints do not bias prices upwards if investors are rational. They argue that in a rational market, traders will recognise the existence of short-sale constraints and will adjust their beliefs such that no overpricing of securities will exist, on average. Rational investors are aware that, due to short-sale constraints, negative information is withheld, so individual stock prices reflect an expected quantity of bad news. If short-constraints prohibit some trades by informed and uninformed traders, constraints reduce unconditional informational efficiency especially with respect to private bad news. Thus the Diamond and Verrechia (1987) model predicts that short-sale constraints will reduce the speed of adjustment to negative information. While the Miller (1977) and Diamond and Verrechia (1987) models have different implications, the overriding theoretical view is that binding short-sale constraints inhibit the incorporation of negative information.

2.2.2 *Empirical findings*

The effect of short-sale constraints on stock prices is ultimately an empirical question. Careful empirical investigation is required to examine the relative validity of the predictions of the foregoing models. Consistent with the Miller (1977) and Diamond and Verrechia (1987) models, the available empirical evidence largely indicates that short-sale constraints hinder price discovery. One key empirical issue is determining an appropriate measure of short-sale constraints. Ideally a perfect test would involve two economies that are identical except for whether or not they have short-sale constraints. However, most tests are conducted out indirectly using measures that attempt to identify stocks subject to short-sale constraints. These measures are outlined in Table 2-1 and include: short-interest (Figlewski, 1981); breadth of ownership (Chen, Hong and Stein, 2002); Institutional ownership (see *inter alia* Nagel, 2005); the cost of short-selling (see *inter alia* Jones and Lamont, 2002); option introductions (Danielsen and Sorescu, 2001); stock option lockups (Ofek and Richardson, 2003); experimental markets (Haruvy and Noussair, 2006); and institutional changes (see *inter alia* Chang, Chang and Yu, 2007).

Table 2-1 Literature summary: Measures of short-sale constraints

This table summarises the measures employed to proxy for short-sale constraints and the main results.

Study	Short-sale constraint	Sample period	Main Findings
Figlewski (1981)	Short-interest	1973-1979	While the least shorted firms produce positive abnormal returns with high statistical significance, the most shorted deciles do not produce statistically significant negative abnormal returns. Figlewski (1981) concludes that the prices of stocks for which there is relatively more adverse information among investors would tend to be high.
Chen, Hong and Stein (2002)	Institutional ownership	1979-1998	The change in the number of mutual funds holding a stock is positively related to subsequent stock returns. The results imply that stocks experiencing declines in breadth of ownership—a proxy for short-sale constraints becoming more tightly binding—subsequently underperform those for which breadth has increased.
Nagel (2005)	Institutional ownership	1980-2003	Underperformance in growth stocks and high-dispersion stocks is concentrated among stocks with low Institutional ownership.
Jones and Lamont (2002)	Shorting costs	1926-1933	Stocks which are expensive to short have low subsequent returns, consistent with the hypothesis that they are overpriced.
Ofek, Richardson and Whitelaw (2004)	Shorting costs	1999-2001	Stocks with abnormally low rebate rates have lower subsequent returns.

Table 2-1 – Continued

Isaka (2007)	Shorting costs	1998-2001	Short-sale constraints reduce the adjustment speed of stock prices to negative information.
Boehme, Danielsen and Sorescu (2006)	Shorting costs/short-interest/option listing	1988-2002	Using a variety of measures for heterogeneity of investor opinion (e.g., analyst recommendations, return volatility) they find strong support for Miller's (1977) hypothesis on how short-sale constraints, simultaneously with divergence of opinion, are linked to overpricing. Importantly, stocks are not systematically overvalued when either one of these two conditions is not met.
Figlewski and Webb (1993)	Option listing	1973-1983	High relative short-interest on a stock is associated with future underperformance in terms of its returns, because constraints on short-sales cause negative information to be underweighted in the market price. This finding is weaker for optionable stocks, which is consistent with the argument that the existence of options reduces the information inefficiency caused by short-selling constraints.
Sorescu (2000)	Option listing	1981-1995	The introduction of options for a specific stock causes its price to fall. This is consistent with the idea that options allow negative information to become impounded into the stock price.
Danielsen and Sorescu (2001)	Option listing	1981-1995	Option introductions are associated with negative abnormal returns in underlying stocks. This implies that negative information is slower to be incorporated into prices when shorting is constrained.
Ofek and Richardson (2003)	Stock option lockups	1998-2000	Short-sale constraints have a considerable and persistent negative impact on subsequent stock returns, also supporting the argument that stock prices do not fully incorporate information under short-sale constraints.

Table 2-1 – Continued

Haruvy and Noussair (2006)	Experimental markets	N/A	Short-selling has the effect of reducing market prices.
Biais, Bisere and Decamps (1999)	Unique institutional features	1996	Short-sale constraints reduce the speed at which negative information is impounded into the price.
Bris, Goetzmann and Zhu (2007)	Unique institutional features	1990-2001	The evidence is weakly consistent with short-selling facilitating more efficient price discovery at the individual security level.
Chang, Chang and Yu (2007)	Unique institutional features	1994-2003	Significant negative cumulative mean abnormal returns after stocks are added to the list of designated securities for short-selling. They regress these abnormal returns over variables that proxy for the dispersion of investor opinions and find that the decline increases with the divergence of investor opinions.
Asquith, Pathak and Ritter (2005)	Short-interest (shorting demand) and Institutional ownership (shorting supply)	1988-2002	Stocks in the highest percentile of short-interest (their proxy for shorting demand) and the lowest third of Institutional ownership (their proxy for shorting supply) underperform by 215 basis points per month.
Cohen, Diether and Malloy (2007)	Amount on loan (shorting demand) and lending fee (shorting supply)	1999-2003	Increases in shorting demand have economically large and statistically significant negative effects on future stock returns. The cross-sectional relation between high shorting costs and future negative returns, documented previously in the literature, is only present when shorting costs are driven by increases in shorting demand. The findings suggest that the shorting market is, most importantly, a mechanism for private information revelation.

The earliest empirical tests examine short-sale constraints using short-interest as a proxy for shorting demand. Figlewski (1981) tests the effect of short-sale constraints by looking at the relationship between the level of short-interest and subsequent stock returns. Figlewski (1981) argues that short-interest proxies for the level of shares that would be sold short if short-sale constraints were nonexistent, and therefore, the amount of adverse information that was excluded from the market price. Using a sample from 1973 to 1979, he documents weak evidence that more heavily shorted firms underperform less heavily shorted firms. While the least shorted firms produce positive abnormal returns with high statistical significance, the most shorted deciles do not produce statistically significant negative abnormal returns. Figlewski (1981) concludes that the prices of stocks for which there is relatively more adverse information among investors tend to be high.

In many subsequent studies authors criticise the use of short-interest as a proxy for shorting demand (see *inter alia* D'Avolio, 2002, Chen, Hong and Stein, 2002 and Jones and Lamont, 2002). Chen, Hong and Stein (2002) note that the majority of stocks have virtually no short-interest outstanding at any given point in time. Thus if the test design involves tracking the abnormal returns of a portfolio of high short-interest stocks, this portfolio will by definition be small, thereby potentially reducing the power of any tests, as well as calling into question the generalisability of the results. Jones and Lamont (2002) note that using short-interest as a proxy for shorting demand is problematic, because the quantity of shorting represents the intersection of supply and demand. Demand for shorting should respond to both the cost and benefit of shorting the stock, so that stocks that are very costly to short will have low short interest. Stocks that are impossible to short have an infinite shorting cost, yet the level of short-interest is zero. Thus short-interest can be negatively correlated with shorting demand, overpricing, and shorting costs. For example, a low level of short-interest may not indicate low shorting demand: stocks that are impossible to short could have a large shorting demand, yet the level of short-interest is zero. Direct supporting evidence is found in D'Avolio (2002). For stock deciles sorted by short interest, neither the mean loan fee nor the percentage of stocks with high loan fees in the portfolio is monotonic in the actual short interest. This finding shows that short-interest is not an effective measure of short-sale constraints.

Another strand of the literature utilises institutional ownership to proxy for short-sale constraints. This literature argues that short-sale constraints are most likely to bind among stocks with low institutional ownership because of institutional constraints. Most professional investors never short-sell, and hence cannot trade against overpricing of stocks they do not own. Consistently, Almazan, Brown, Carlson and Chapman (2000) find that only about 30% of mutual funds are allowed by their charters to sell short and only 2% actually do sell short. Further, short-selling can be costly and short-sellers must borrow shares from an investor willing to lend. If loan supply is sparse, the short-seller may have to pay a significant fee. D'Avolio (2002) shows that the main suppliers of stock loans are institutional investors. He finds that the degree of institutional ownership explains much of the variation in loan supply across stocks, and stocks with low institutional ownership are more expensive to borrow.

Chen, Hong and Stein (2002) posit that short-sale constraints are strongly linked to the availability of shares to borrow, and argue that when the number of institutions (mutual funds) owning a stock increases or decreases, short-sale constraints are either relaxed or tightened, respectively. Chen, Hong and Stein (2002) argue that a more reliable proxy for how tightly short-sale constraints bind (and hence for the amount of negative information withheld from the market) can be constructed by looking at data on breadth of ownership, where breadth is defined as the number of investors (mutual funds) with long positions in a particular stock. Specifically, when breadth for a stock is lower, more investors are sitting on the sidelines, with their pessimistic valuations not registered in the stock's price. Using quarterly data from 1979–1998, Chen, Hong and Stein (2002) find that the change in the number of mutual funds holding a stock is positively related to subsequent stock returns. The results imply that stocks experiencing declines in breadth of ownership—a proxy for short-sale constraints becoming more tightly binding—subsequently underperform those for which breadth has increased.

Nagel (2005) modifies this proxy by considering the percentage of shares owned by institutions instead of the number of institutions owning shares. During the sample period (1980–2003), Nagel (2005) finds that underperformance in growth stocks and high-dispersion stocks is concentrated among stocks with low institutional ownership. This is consistent with the idea that short-sale constraints hold off negative opinions for these stocks. However, Nagel (2005) also finds that when he combines his sample period with that in Chen, Hong and Stein (2002), there is no longer a reliable pattern during the 1980 to 2003 period between breadth of mutual fund ownership and future returns. The use of institutional ownership is an improvement over short-interest as a proxy for short-sale constraints. However, various issues arise from these studies, including the use of mutual fund data. Cohen, Diether and Malloy (2007) note that mutual fund and institutional investment, aside from representing only a portion of the investing universe, are also driven by non-shorting considerations such as investment style. Further, the measure is based not on the entire investing universe—as the theory suggests it should be—but rather on just the mutual-fund sector. Chen, Hong and Stein (2002) note that this is an important limitation, and suggest interpreting the results with some caution due to the possibility that the results do not fully reflect binding short-sale constraints, but rather potential superior stock-picking skill on the part of mutual fund managers.

Short-selling can be expensive as stock needs to be borrowed from an available lender who charges a fee to the short-seller. Given this cost, another strand of the literature analyses direct measures of shorting costs as a proxy for short-sale constraints (see *inter alia* Jones and Lamont, 2002, Geczy, Musto and Reed 2002). Jones and Lamont (2002) provide a description of shorting costs and a description of the motivation for its use as a proxy for short-sale constraints. The most commonly used metric is the rebate rate, and in particular, the spread between the rebate rate and the market interest rate. As described in Section 1.1.2, the difference or spread between the interest rate on cash funds and the rebate rate is a direct cost to the short-seller, and is often referred to as the loan fee. The rebate rate serves to equilibrate supply and demand in the stock lending market, much like the 'repo' rate in the fixed income market.

Given rebate rates are not publicly available, empirical research is typically limited to proprietary databases over short time periods. Jones and Lamont (2002) examine a unique data set of shorting costs for New York Stock Exchange (NYSE) stocks from

1926 to 1933. During this period, the cost of shorting certain NYSE stocks was set in the 'loan crowd', a centralised stock loan market on the floor of the NYSE. A list of loan crowd stocks and their associated loaning rates was printed daily in the *Wall Street Journal*. From this public record, Jones and Lamont (2002) collect eight years of data on an average of 90 actively traded stocks per month. The results show that stocks which are expensive to short have low subsequent returns, consistent with the hypothesis that they are overpriced. Stocks that newly enter the borrowing market exhibit substantial overpricing. Prices rise prior to entering the loan list, peak immediately before a stock enters the loan list, and subsequently fall as the apparent overpricing is corrected. However, given the period of analysis (1926-1933), questions arise as to the applicability of the results to current markets.

Using more recent data from a single lender (November 1998 through October 1999), Geczy, Musto and Reed (2002) also measure the effect of short-selling costs and constraints on trading strategies that involve short-selling. Geczy, Musto and Reed (2002) report that the higher costs of borrowing stocks that are on 'special' do not eliminate the abnormal returns from the short-selling strategies they examine.[17] They also conclude that short-sale constraints are unable to explain anomalous patterns in stock returns. However, the use of data from a sole lender and over a short time period may not be generalisable to the entire market. D'Avolio (2002), also using a database from a single lender for the period April 2000 through September 2001, reports that only 9% of the stocks in his sample are 'on special' on a typical day. The other 91% have a rebate rate approximately equal to the Fed funds overnight rate. He also finds

[17] Stocks that are expensive to borrow are known as 'special', 'specials' or 'on special'.

that stocks that are on special have higher short-interest ratios. Ofek, Richardson and Whitelaw (2004), using a proprietary database of rebate rates from July 1999 to December 2001, document that stocks that are on special are more likely to violate put-call parity. Consistent with D'Avolio (2002), they find that 10.8% of their sample stocks have rebate rates more than 100 basis points below the Fed funds rate. Further, they report that stocks with abnormally low rebate rates have lower subsequent returns.

Boehme, Danielsen and Sorescu (2006) obtain rebate rates and loan fee data over the period March 2001 to December 2002. Given the short time period, the authors use the available fee data to validate other constraint proxies and develop a proxy for short-sale constraints. Specifically, for each month from 1988 to 2002, the authors construct a constraint variable which recognises the lending fee and also employs information contained in short-interest and option availability (both measures of constraints). Boehme, Danielsen and Sorescu (2006) emphasise in Miller's (1977) model, if a stock is subject to short-sale constraints but there is no disagreement about the firm value (i.e., there are no optimists or pessimists), then the stock price will not be overpriced. Likewise, if there is high dispersion of opinions (i.e., there are optimists and pessimists), but no short-sale constraints, then both (optimists and pessimists) are able to trade and the market price will not be overvalued. Boehme, Danielsen and Sorescu (2006) address this issue by examining the valuation effects of the interaction between differences of opinion and short-sale constraints. Using a variety of measures for heterogeneity of investor opinion (e.g., analyst recommendations, return volatility), they find strong support for Miller's hypothesis on how short-sale constraints, simultaneously with divergence in opinion, are linked to overpricing. Importantly, stocks are not systematically overvalued when either one of these two conditions is not met.

Isaka (2007) employs stock lending fees for the Japanese market to examine the effects of short-sale constraints on the informational efficiency of stock prices. The author aims to test the Diamond and Verrechia (1987) hypothesis that short-sale constraints reduce the speed of adjustment to stock prices in response to private information and cause a sharp decline in prices when announcements occur that reveal negative information to the public. Results indicate that short-sale constraints reduce the adjustment speed of stock prices to negative information before the announcements of revised earnings forecasts disclosed by firms in the Tokyo Stock Exchange from July 1998 to December 2001. Cumulative abnormal returns (CARs) of the stocks with high short-sales costs are insensitive to negative information on pre-announcement days, but the CARs of these stocks become significantly lower than the CARs of the stocks with low short-sales costs when the announcements reveal negative information to the public.

The proxies for short-sale constraints reviewed so far include various measures of shorting supply (i.e., institutional ownership or lending fees) and demand (i.e., short interest). Another strand of the literature attempts to examine short-sale constraints directly using institutional changes. The first studies to use institutional changes as a proxy for short-sale constraints examine the listing of exchange-traded options (see *inter alia* Figlewski and Webb, 1993, Sorescu, 2000 and Danielsen and Sorescu, 2001). Options can facilitate shorting, because options can be a cheaper way of obtaining a short position and allow short-sales constrained investors to trade with other investors who have better access to shorting. To the extent that the listing of publicly traded options effectively facilitates short-selling, it is expected that option listings will be associated with negative underlying stock price reactions and with increases in relative short interests (Danielsen and Sorescu, 2001).

Figlewski and Webb (1993) show that optionable stocks exhibit significantly higher levels of short-interest than stocks without options. They argue that options trading creates a channel which effectively allows investors who are constrained from taking direct short positions to short a stock through the options market. Figlewski and Webb (1993) suggest that the listing of options artificially alleviates short-sale constraints and may also increase information efficiency in the market. They demonstrate that high relative short-interest on a stock is associated with future underperformance in terms of its returns, because constraints on short-sales cause negative information to be underweighted in the market price. This finding is weaker for optionable stocks, which is consistent with the argument that the existence of options reduces the information inefficiency caused by short-selling constraints. Similarly, Sorescu (2000) finds that in the period 1981–1995 the introduction of options for a specific stock causes its price to fall. This is consistent with the idea that options allow negative information to become impounded into the stock price. Danielsen and Sorescu (2001) also examine stock returns following option listings over the period 1981 to 1995. Danielsen and Sorescu (2001) find that option introductions are associated with negative abnormal returns in underlying stocks. This implies that negative information is slower to be incorporated into prices when shorting is constrained.

Ofek and Richardson (2003) examine a unique institutional feature (stock option lockups) as a proxy for short-sale constraints. Given lockup agreements represent a stringent form of short-sales constraint (investor cannot sell the share), they argue that lockup expirations are equivalent to loosening a short-sales constraint. The results show that short-sale constraints have a considerable and persistent negative impact on subsequent stock returns, also supporting the argument that stock prices do not fully incorporate information under short-sale constraints. Consistently, Haruvy and Noussair (2006), using a series of experimental markets, show that short-selling has the effect of reducing market prices. However, they find that allowing a sufficiently large short-selling capacity reduces prices to levels below fundamental values. This suggests that allowing short-selling overcompensates for bubbles and leads to prices lower than fundamental values. In financial asset markets, this could translate into a misallocation of capital. Biais, Bisere and Decamps (1999) examine a unique feature on the Paris Bourse where several stocks are traded on a spot basis, while others are traded on a monthly settlement. The authors argue that short-sale constraints are more likely to be binding in stocks traded on a spot basis. Consistent with Diamond and Verrechia (1987), results indicate that short-sale constraints reduce the speed at which negative information is impounded into the price.

Bris, Goetzmann and Zhu (2007) use cross-sectional and time-series information from 46 equity markets around the world to examine whether short-sales restrictions affect the efficiency of the market and the distributional characteristics of individual as well as market returns. Information regarding the history and current practice of short-sales restrictions from market regulators, investment banks, and institutional investors specialising in short-sales is obtained. This data set allows a characterisation of each country in terms of the legality, as well as practice, of short-selling for the period 1990 to 2001. Bris, Goetzmann and Zhu (2007) do not carry out tests of overvaluation directly but examine whether short-sales are associated with more cross-sectional variation in equity returns, based on the assumption that more efficient price discovery results in higher idiosyncratic risk and less price co-movement. The evidence is weakly consistent with short-selling facilitating more efficient price discovery at the individual security level.

Nilsson (2008) examines a unique institutional feature in Sweden to examine the effect of short-sale constraints on asset prices. Between 1980 and the end of 1991, banks and brokerage houses were prohibited by law from participating in stock lending/borrowing transactions; thus a marketplace for lending and borrowing stocks in Sweden did not exist during this period. Further, in 1985 the derivatives exchange, OM, was established and began trading stock options. Between 1985 and 1991, a rather unusual situation prevailed in Sweden where stock options were traded, but the underlying stock was virtually impossible to short. At the end of 1991 the law prohibiting banks and brokerage houses from being involved in stock lending and borrowing was abolished, and several market places were established. Nilsson (2008) finds the impact on pricing is consistent with a short-sale constraint and access to international shorting markets can alleviate local short-sale constraints.

Chang, Chang and Yu (2007) offer the only direct examination of the relationship between short-sale constraints and stock overvaluation. They use the unique regulatory feature on the Hong Kong market that uses a short-sale approved list that is revised over time. This unique market structure enables the authors to trace stock price movements before and after stocks are added to the official list, controlling for the other characteristics of the sampled stocks. Moreover, since short-sales restrictions for different stocks are released at different times, the cross-sectional analysis suffers less from the potential confounding effects of other concurrent events. They find significant negative cumulative mean abnormal returns after stocks are added to the list of designated securities for short-selling. They regress these abnormal returns over variables that proxy for the dispersion of investor opinions and find that the decline increases with the divergence of investor opinions. These results provide possibly the strongest evidence consistent with Miller's (1977) theory.

Finally, a recent strand of literature, which emanates from Asquith, Pathak and Ritter (2005), recognises the competing effects of shorting supply and shorting demand, arguing that stocks with high shorting demand and low shorting supply are the most likely to face binding short-sale constraints. Asquith, Pathak and Ritter (2005) posit that short-interest ratios are a proxy for short-sale demand and institutional ownership is a proxy for lendable supply. They show that stocks in the highest percentile of short-interest (their proxy for shorting demand) and the lowest third of institutional ownership (their proxy for shorting supply) underperform by 215 basis points per month during the 1988 to 2002 period on an equal-weight basis.

Cohen, Diether and Malloy (2007) extend this research by using actual data on loan fees and loan amounts to decompose the effect on stock prices into the part that is due to shorting demand, and the part that is due to shorting supply. The proprietary database contains stock lending activity from a large institutional investor and contains rebate rates, number of shares on loan and collateral amounts/rates, from

September 1999 to August 2003. Employing an identification strategy that isolates shifts in the supply and demand for shorting, the results show that increases in shorting demand have economically large and statistically significant negative effects on future stock returns. However, the authors do not find strong evidence that shifts in shorting supply are linked to future returns. These findings suggest that private information and/or additional non-price costs of shorting are important aspects of the link between the shorting market and stock prices, while the short-run effects of relaxing/tightening short-sale constraints are less important. Cohen, Diether and Malloy (2007) also show that the cross-sectional relation between high shorting costs and future negative returns, documented previously in the literature, is only present when shorting costs are driven by increases in shorting demand. The results of Cohen, Diether and Malloy (2007) cast doubt on the view that the primary link between the shorting market and future stock returns is due to costly market frictions. The findings suggest that the shorting market is, most importantly, a mechanism for private information revelation.

2.2.3 Information content of short-selling

The theoretical and empirical evidence presented above largely indicates that short-sale constraints hinder price discovery and lead to less efficient asset pricing. The evidence also indicates that removing short-sale constraints results in negative abnormal returns as previously overpriced securities are sold. An implication of these studies is that short-sellers remove the upward price bias from stock prices. Given short-selling removes upward biases in prices, this suggests that on average short-sellers are able to identify overpriced securities and may be informed. Diamond and Verrechia (1987) suggest that, since short-sellers do not have the use of sale proceeds, market participants never short for liquidity reasons, which *ceteris paribus* implies relatively few uninformed short-sellers. Consequently, if informed traders are more likely to engage in short-selling, high short-interest conveys adverse information, implying a negative relationship between short-interest and stock returns. There is a growing body of literature which examines the information content of short-selling and ultimately examines whether short-sellers are informed. This section reviews these studies, which largely indicate that short-sellers are informed (see *inter alia* Desai, Ramesh, Thiagarajan and Balachandran, 2002 and Boehmer, Jones and Zhang, 2008).

As previously discussed, while there are many reasons for short-selling, the 'speculative motive' associated with expected decreases in a stock's market value receives the most notoriety. Under this motive, a high level of short-interest or an increase in short-interest can be considered bearish, since it reflects pessimism among market participants concerning the future level of stock prices. Alternatively, a high or increasing level of short-interest could be interpreted as bullish since all short positions must eventually be covered, implying an increase in demand for the stock. Given the availability of data on short-selling (short-interest), early studies examine the relationship between short-interest and stock returns. These early studies use monthly short-interest data (number of shares sold short at a particular point in time each month) and find mixed results.

The earliest reported short-selling data, short-interest statistics in the United States, did not begin until May 1931, and analysis of data from the subsequent decade reveals no systematic relationship between a stock's short-interest and price changes (Macaulay and Durand, 1951). Biggs (1966) studied a sample of 33 stocks: for 14 stocks there was a positive relationship between short-interest and subsequent price, for 16 stocks the relationship was negative, and there was no relationship for the remaining three stocks. Seneca (1967) uses a second-order autoregressive scheme to study the effect of a modified short-interest ratio, lagged two weeks, on the deflated 1946-65 Standard and Poor's 500 stock index. He includes deflated corporate dividends as a regressor, to account for other factors, such as the economy. He finds his short-interest variable to have a significant negative effect. He hypothesises that short-interest changes are reflections of investors' expectations regarding future stock prices. Seneca's (1967) study was criticised by Hanna (1968) for the shortness of the 15-day lag and for the apparent confusion between the short-interest and the short ratio.

Mayor (1968) tests both aggregate (Standard and Poor's 500 stock index) and individual (14 randomly selected, frequently shorted common stocks) for 1962-1966 data by regressing the index level or individual stock price on the appropriate short position lagged two weeks. He uses four different regression models. He also simulates short-interest trading activities. He concludes: "Contrary to public opinion, the view which emerges from this study is that there is no significant relationship between short-interest levels and stock prices." Consistently, Smith (1968) does not find any relationship between rising short-interest levels and stock prices. Smith (1968) reports that "strategies of buying stocks with high short positions did not improve on random selection of stocks." McEnally and Dyl (1969) simulate randomly selling stocks for 1961-1965, a period of rising stock prices. They find that short-sellers, on average, lose money, with their losses being greater the longer they hold the position. Heiby (1970) tests complicated rules to profit from knowledge of the short-sales by New York Stock Exchange (NYSE) members. He reports a 50% average annualised profit through trading based on his rules.

McDonald and Baron (1973) analyses the relationship between the risk of stocks and the frequency of the reported short positions. They find that riskier stocks often have higher levels of short-interest than others, and also have more highly variable short positions. They find that in a period of generally rising stock prices, short-sellers on average earn negative returns. Kerrigan (1974), using a sample of 200 firms, finds that the short ratio can be used to predict stock price movements. He finds a negative correlation between the level of the short ratio and the subsequent level of the S&P 500 Index. He concludes, however, that this is probably caused not by changes in the level of short interest, but by changes in the level of trading volume. According to Kerrigan (1974), trading volume would be high in bull markets and low in bear markets. Hanna (1976), using various levels of filters, finds that it is possible to earn significantly higher returns than a buy-and-hold strategy by trading on the assumption that large increases in the short-interest are bullish and large declines are bearish. Hanna (1976) hypothesises that when speculative expectations become extreme, stock prices are likely to revert in the unanticipated direction. He tests the hypothesis with a model which uses changes in individual stocks' short-interest ratios (relative to their average daily trading volume) to measure shifts in investors' speculative expectations. He finds that returns generated by the model significantly exceed returns generated by other strategies, e.g., random trading and buy-and-hold. He concludes, "The test indicates a systematic tendency for investors to over-discount events when an overwhelming majority share the same optimism (pessimism) about future stock prices."

Hurtado-Sanchez (1978) examines the relationship between short-interest and stock returns for individual stocks. Hurtado-Sanchez (1978) attempts to correct systematically for both the risk and general state of the market using the capital asset pricing model. None of the previous studies (except for McDonald and Baron, 1973, and perhaps Seneca, 1967) attempts any correction for such factors. This study has larger individual stock samples than any of the other studies. However, it covers a shorter time period. A more robust statistical technique than regression analysis is used, non-parametric analysis of variance. Hurtado-Sanchez (1978) finds that an investor cannot profit from knowledge of the short-interest data. However, in a departure from previous work, this study offers evidence that short-sales act as a stabilising force on the movement of stock prices.

In contrast to Hurtado-Sanchez (1978), Figlewski (1981) documents that stocks with high short-interest in one period tend to have low risk-adjusted returns in the following period. More recently, Brent, Morse and Stice (1990) document that, like Hurtado-Sanchez (1978), periods of high short-interest tend to follow periods of high returns. Brent, Morse and Stice (1990) show that the security returns in the month following an increase in short-interest are 0.1% greater than security returns in the month following a decrease in short interest. These differences are generally not significant and suggest that a trading strategy based on changes in short-interest would be unsuccessful in the short run. Senchack and Starks (1990) test stock price reactions to the announcement of a substantial increase in short interest. Stocks with unexpected increases in short-interest are found to generate negative abnormal returns for a short period around the announcement date. The results also indicate that an unusual increase in short-interest is non-informative when there are options listed over the stocks.

The early literature, discussed so far, provides mixed findings on the relationship between short-interest and stock returns. Several studies find that the levels of (or the changes in) short-interest are associated with changes in stock returns, while other studies do not. In the studies where an association is observed, its sign is positive in some cases and negative in others. Desai, Ramesh, Thiagarajan and Balachandran (2002) argue that the weak results could be due to the use of small and/or biased samples. The early data is likely to exclude firms with large and significant short positions relative to the shares outstanding. Also, since a typical firm has short-interest of less than 1% of the shares outstanding, and since most firms have little or no short interest, samples chosen on a random basis lack the statistical power to detect a significant association between short-interest and stock returns.

Desai, Ramesh, Thiagarajan and Balachandran (2002) attempt to correct for these concerns by investigating the relationship between the level of short-interest and the stock returns in Nasdaq firms using monthly short-interest data for the universe of Nasdaq firms from June 1988 to December 1994. The empirical tests strongly support the view that short-interest is a bearish signal and that the information content of this signal is increasing in the magnitude of short interest. Specifically, heavily shorted firms experience significant negative abnormal returns ranging from 20.76 to 21.13% per month after controlling for the market, size, book-to-market, and momentum factors. Elfakhani (2000) also investigates the relationship between short-interest and subsequent returns. The results support the notion that short-sellers made correct predictions of price movements during the sampling period 1986-1990.

Dechow, Hutton, Meulbroek and Sloan (2001) use monthly short-interest to examine the trading strategies of short-sellers. The authors document a strong relation between the trading strategies of short-sellers and ratios of fundamentals to market prices. Firms with low ratios of fundamentals (such as earning and book values) to market values are known to have systematically lower future stock returns. The authors find that short-sellers position themselves in the stock of such firms, and then cover their positions as the ratios mean-revert. They also show that short-sellers refine their trading strategies to minimise transactions costs and maximise their investment returns. The evidence is consistent with short-sellers using information in these ratios to take positions in stocks with lower expected future returns. A possible explanation for the results is that short-sellers are sophisticated investors who play an important role in keeping the price of stocks in line with fundamentals. Consistently Kot (2007), using a sample from 1988-2002 on the Nasdaq, documents that short-sellers prefer stocks with low fundamental market ratios, such as book-to-market.

Arnold, Butler, Crack and Zhang (2005) also propose a potential reason for the mixed results in the early literature. As mentioned above, the Taxpayer Relief Act (TRA97) in the United States eliminated the opportunity to defer capital gains taxes using option strategies like shorting against the box. Arnold, Butler, Crack and Zhang

(2005) use a large sample of short-interest announcements, and document that an increase in the costs of short-selling (TRA97) increases the negative information content of short-interest announcements. Particularly for NYSE stocks, short-interest announcements after TRA97 convey significantly more negative sentiment than those before TRA97. In contrast to the findings of Desai, Ramesh, Thiagarajan and Balachandran (2002), it is no longer true that the negative relationship between short-interest and subsequent stock price performance holds only in the most heavily shorted stocks. Rather, after TRA97, short-interest announcements convey negative information even for stocks with moderate levels of short interest. The results of this study possibly explain the lack of uniform results in the prior literature.

Most recently, Boehmer, Huszár and Bradford (2010) examine monthly short-interest data from 1988-2005 for stocks from NYSE, Amex and Nasdaq. Consistent with Arnold, Butler, Crack and Zhang (2005), the authors document that stocks with relatively high short-interest subsequently experience negative abnormal returns, but the effect can be transient and of debatable economic significance. The results also show that both positive and negative information apparently known to short-sellers is not incorporated in stock prices, casting doubt on the critical asymmetry between the way that good and bad news is revealed to market participants. However, they still find evidence that short-sellers are able to identify overvalued stocks to sell, and appear adept at avoiding undervalued stocks.

Examining monthly short interest, Karpoff and Lou (2010) examine whether short-sellers detect firms that misrepresent their financial statements, and whether their trading conveys external costs or benefits to other investors. The results show that abnormal short-interest increases steadily in the 19 months before the misrepresentation is publicly revealed, particularly when the misconduct is severe. Short-selling is associated with a faster time-to-discovery, and it dampens the share price inflation that occurs when firms misstate their earnings. These results indicate that short-sellers anticipate the eventual discovery and severity of financial misconduct. Short-sellers also convey external benefits, helping to uncover misconduct and keeping prices closer to fundamental values.

Cohen, Diether and Malloy (2007) argue that the failure to find a consistent relation between short-interest and abnormal returns in the early literature could be due to the problematic nature of short interest. For example, a low level of short-interest may not indicate low shorting demand. Stocks that are impossible to short could have a huge shorting demand, yet the level of short-interest is zero. The weak results could also be due to the typical focus on levels of short interest, rather than changes in short interest. Further, Cohen, Diether and Malloy (2007) find that almost half of the securities lending contracts they study are closed out within two weeks. Diether, Lee and Werner (2009a) indicate that approximately 40% of trading volume involves a short-seller. In contrast, short-interest represents only about 4% of shares outstanding. Boehmer, Jones and Zhang (2008) suggest that this discrepancy is due to short-sellers on average maintaining their positions for a much shorter period of time. This suggests that monthly data could be inadequate for understanding the trading practices of short-sellers. Until recently, short-selling data was only available with a monthly frequency. However, higher-frequency data allows for a greater degree of granularity in which to study the information content of short-sellers.

Christophe, Ferri and Angel (2004) provide the first evidence of short-selling at the daily level. The authors take a different approach, using a unique data set to explore key features of short-sales transactions prior to the earnings announcements of 913 Nasdaq firms. If short-sellers are primarily informed traders, atypical increases in short-selling should occur with some frequency prior to negative earnings surprises, and unusual declines in short-selling should appear before favourable announcements. The results show that daily flows of short-sales are concentrated prior to disappointing earnings announcements, which suggests short-sellers have access to private information.

Along the same line, Christophe, Ferri and Hsieh (2010) study short-selling prior to the release of analyst downgrades in a sample of 670 downgrades of Nasdaq stocks between 2000 and 2001. They find abnormal levels of short-selling in the three days before downgrades are publicly announced. Further, the pre-announcement abnormal short-selling is significantly related to the subsequent share price reaction to the downgrade, and especially so for downgrades that prompt the most substantial price declines. Further evidence suggests that tipping, where short-sellers short a firm’s stock by taking advantage of the tip they receive from a brokerage firm about a forthcoming downgrade, is more consistent with the data than the prediction explanation which posits that short-sellers successfully predict downgrades on the basis of public information about a firm’s financial health. Downgraded stocks with high abnormal short-selling perform poorly over the subsequent six months by comparison with those with low abnormal short-selling. Overall, the results support the hypothesis that short-sellers are informed traders and exploit profitable opportunities provided by downgrade announcements.

Using proprietary data, Boehmer, Jones and Zhang (2008) examine daily short-sale flow executed at the NYSE over the period January 2000 through April 2004. They find that heavily shorted stocks significantly underperform lightly shorted stocks (over a 20-day holding period), and they argue that the difference exceeds trading costs. Similarly, Diether, Lee and Werner (2009a) use tick data on all short-sales executed in the US during 2005 (these data are available only since January 2, 2005). Consistently, they find that portfolios comprising a long position in lightly shorted stocks and a short position in heavily shorted stocks have positive abnormal returns, though the amount of trading required to capture the returns is considerable. Further evidence that short-sellers are informed is provided by Clunie, Moles and Pyatigorskaya (2009), who examine how short-sellers react to losses. Using daily data on stock lending, they estimate the average price at which short positions were initiated, thus permitting a study of short-sellers' responses to their own book losses. Results show that short-sellers close their positions in response to losses and not simply in response to rising share prices. Short-sellers do not exhibit an aversion to realising losses, but instead accept their losses or 'mistakes' systematically. Stocks subject to short-covering in this manner do not subsequently underperform the market, and so there is no evidence of an investment performance cost (other than transaction costs) associated with immediately covering short positions that fall to an accounting loss.

The more recent results from studies which examine daily short-sales uniformly indicate that short-sellers are informed. Further evidence of this is shown at the intraday level by Aitken, Frino, McCorry and Swan (1998). The authors examine short-sale orders placed and trades executed on the ASX. They investigate the market reaction to short-sales on an intraday basis in a market setting where short-sales are transparent immediately following execution. They document a mean reassessment of stock value following short-sales of up to 20.20% with adverse information impounded within 15 minutes or 20 trades. Short-sales executed near the end of the financial year and those related to arbitrage and hedging activities are associated with a smaller price reaction; trades near information events precipitate larger price reactions. The evidence is generally weaker for short-sales executed using limit orders relative to market orders. Overall the results are consistent with the notion that short-sellers are informed.

2.3 Impact of short-selling on market quality

The previous section examines the pricing implications of short-selling and the evidence largely indicates that short-sale constraints hinder price discovery. Despite the almost universal evidence regarding the benefits for asset pricing, short-selling is regarded as a controversial technique by many, particularly in times of falling markets. Short-selling is often associated with panic selling, high volatility and market crashes, which can lead to potential problems such as market abuse, disorderly markets and settlement failure. In particular, naked short-selling is often most heavily criticised and is outlawed in many markets. This section reviews the theoretical and empirical literature on the impact of short-selling on market quality. Market quality is not easily defined and can encompass many aspects including market volatility, liquidity and pricing efficiency. Given that the previous section examines pricing efficiency, this section focuses on market volatility and liquidity. The section concludes by examining the limited literature that focuses on the impact of naked short-selling on market quality.

2.3.1 Impact on volatility

The relationship between short-sales and stock return volatility is a contentious issue and has received limited academic attention. While theoretical models attempt to explain the volatility of stock returns when short-sale constraints are imposed, there is no widely accepted theory on how short-sale constraints affect the volatility of market returns. Hong and Stein (2003) develop a heterogeneous agent model linking short-sale constraints to market crashes. In their model, if certain investors are constrained from selling short, their accumulated unrevealed negative information will not be impounded until the market begins to drop, which further aggravates a market decline and leads to a crash. Therefore, their model predicts a higher frequency of extreme negative stock returns when short-sale constraints are binding. They motivate the model with the observation that the US market displays negative skewness. Hong and Stein's (2003) model is similar to Miller (1977), and they also show how binding short-sale constraints can explain various observed features of crashes such as the fact that they sometimes occur in the absence of sufficiently significant new public information.

Scheinkman and Xiong (2003) develop a behavioural model with heterogeneous investors that exhibit overconfidence to private information. Contrary to the common belief that short-sale constraints stabilise the market, Scheinkman and Xiong (2003) predict a significant decrease in trading volume and price volatility when short-sale constraints are lifted. Consistent with Scheinkman and Xiong (2003), Abreu and Brunnermeier (2002, 2003) document that short-sale constraints can be a direct cause of, or at least a necessary condition for, bubbles and excessive volatility. Bai, Chang and Wang (2006) consider a fully rational expectations equilibrium model, in which investors trade for two reasons, to share risk and to speculate on private information, but face short-sale constraints. Short-sale constraints limit both types of trades, and thus reduce the allocation and informational efficiency of the market. Bai, Chang and Wang (2006) predict higher price volatility when short-selling is restricted, as better-informed investors are held out of the market, and less informed investors perceive the risk as considerably higher. This is consistent with Diether, Lee and Werner (2009a), who document that short-sellers tend to be contrarian traders, with a stabilising effect on the market.

Zheng (2008) samples intraday short-sales transaction data from the NYSE to study short-selling around company earnings announcements, and documents that when the earnings announcement is above expectations, short-sellers act as contrarians. Ho (1996) documents that the daily volatility of stock returns increases when short-sale constraints are imposed. Ho (1996) utilises an event where the Stock Exchange of Singapore suspended trading for three days from December 2, 1985 to December 4, 1985. When trading was resumed on December 5, 1985, contracts could only be executed on an immediate delivery basis (i.e., delivery and settlement within 24 hours), which implies that short-selling was severely restricted.

Charoenrook and Daouk (2005) examine the effect of market-wide short-sale restrictions on skewness, volatility, probability of market crashes, liquidity, and expected market returns. They collect data from December 1969 through December 2002 on the history of short-sale regulation and feasibility from 111 countries that have stock markets. They also collect data on the history of put option trading, as Figlewski and Webb (1993) show that option trading ameliorates short-sale constraints. They consider both the legality and feasibility of short-selling or put option trading. They test feasibility because many countries do not have rules prohibiting short-selling, yet no short-selling takes place for lack of necessary institutions that facilitate stock borrowing across market participants. Conversely, some countries officially prohibit short-selling, yet short-selling takes place routinely via offshore markets. An indicator that determines whether short-selling is possible is constructed using information on the regulation and feasibility of both short-selling and put option trading. Using this indicator, the authors conclude that when short-selling is possible, the aggregate returns are less volatile.

Hueng (2006) examines a sample that fits the Hong and Stein (2003) model assumptions to test the model in a time-series setting. The Chinese stock markets are young and lack stock lending mechanisms. The index derivatives are still at the early stage of development. Therefore, it is very difficult to short-sell Chinese stocks. Using daily data of the Shanghai and Shenzhen composite indexes from June 1995 to August 2001, they find that higher trading volume today predicts a more negatively skewed distribution for tomorrow's stock return. Thus, the Hong and Stein (2003) model is supported in the Chinese stock markets.

While the above theoretical and empirical evidence suggests that short-sale constraints have an adverse effect on volatility, Allen and Gale (1991) provide an exception to this view. Allen and Gale (1991) describe a model of general equilibrium with incomplete markets in which firms can innovate by issuing arbitrary, costly securities. When short-sales are prohibited, firms behave competitively, and equilibrium is efficient. However, without the presence of short-sale constraints, financial innovation is not necessarily efficient and markets may not be complete. The authors highlight that the potential for financial innovation renders short-selling a destabilising influence in the economy. This is potentially interesting, given short-sales tend to be allowed in major markets where financial innovations occur. Bernardo and Welch (2004) develop a model that shows how the fear of financial crisis, instead of a real liquidity shock, is the true cause of financial crises. One implication of their model is that constraints which hinder market participants from front-running other investors can effectively prevent financial crises from happening, which is consistent with the finding of Allen and Gale (1991) that short-sales can potentially destabilise the economy.

Kraus and Rubin (2002) derive a stylised model predicting the impact of index options introduction (a form of reduction in short-sale constraints) on the volatility of stock returns when short-selling of stocks is prohibited. Their model predicts volatility may increase or decline, depending on the model parameter values. As an empirical illustration, they study the effect of index option initiation in Israel. Options were introduced in Israel at a time when short-sales were prohibited, presenting an opportunity to examine the removal of a short-sale constraint. They find that option introduction was accompanied by an increase in volatility of the underlying index.

Consistently, Henry and McKenzie (2006) find that the Hong Kong market exhibits greater volatility following a period of short-selling and that volatility asymmetry is exacerbated by short-selling. Henry and McKenzie (2006) consider the relationship between traded volume and volatility, allowing for the impact of short-sales. The evidence supports a nonlinear, bi-directional relationship between volume and volatility. Short-selling has a significant impact on this relationship, and results suggest that the Hong Kong market displays greater volatility following a period of short-selling, and that asymmetric responses to positive and negative innovations to returns appear to be exacerbated by short-selling.

Chang, Chang and Yu (2007), using a direct measure of short-sale constraints, find that the volatility of stock returns increases when the constraints are lifted. However, the authors note that increasing volatility of individual stocks is not tantamount to increasing the volatility of the market as a whole. For this reason, and because of the overlapping attributes of the sample, the authors urge caution in inferring the effects of short-sales on market stability. However, the results do provide interesting evidence that relaxing restrictions on short-sales leads to higher return volatility for individual stocks.

Bris, Goetzmann and Zhu (2007) test whether short-sale constraints stabilise or destabilise financial markets by examining the frequency of extreme negative returns and the skewness of both individual stock returns and market returns. They find that in markets in which short-selling is either prohibited or not practised, stock returns at the market level tend to be less, rather than more, negative, which contradicts the prediction of Hong and Stein's (2003) model. However, Bris, Goetzmann and Zhu (2007) fail to identify significant differences in skewness at the individual level, or any significant relationship between the frequency of extreme negative returns and short-sale restrictions.

Alexander and Peterson (2008) and Diether, Lee and Werner (2009b) both use Reg SHO data to analyse the effects on market quality associated with the temporary suspension of price tests (short-sale constraint) on the NYSE and Nasdaq. Diether, Lee and Werner (2009b) find evidence of an economically small, but statistically significant, increase in volatility using intraday returns on the NYSE. Alexander and Peterson (2008) observe an increase in volatility; however, none of the tests indicate that the increase is significant. It should be noted that Diether, Lee and Werner (2009b) describe their observed increase in volatility as 'slight' and conclude that their evidence does not suggest an increase in down-side volatility. Further, both studies find that the results from the Nasdaq are weak and often insignificant relative to those on the NYSE. Overall, Alexander and Peterson (2008) and Diether, Lee and Werner (2009b) observe insignificant or weak increases in daily and intraday return volatility.

Overall, the limited theoretical and empirical evidence presented above provides conflicting predictions regarding the impact of short-sales on volatility. Specifically, the empirical evidence is quite scarce and requires further investigation.

2.3.2 Impact on liquidity

Evidence regarding the impact of short-sales on liquidity is very limited. Diamond and Verrecchia (1987) is possibly the only theoretical study examining changes in short-sale constraints and the effect on liquidity. They examine short-sales prohibitions, where no short-sales are allowed, and short-sale constraints, where investors do not receive the proceeds from short-sales immediately. Under the short-sale constraints set-up, uninformed traders are excluded from the market due to the institutional constraints. Diamond and Verrecchia (1987) argue that a short-prohibition increases the average bid-ask spread. In their model, when the price is far from the true but yet unknown liquidation value, there is more uncertainty in the price, and hence the bid-ask spread is wider. The short-sales prohibition reduces the speed at which the price converges to the true liquidation value, and therefore reduces the speed at which the bid-ask spread narrows over time. This increases the average bid-ask spread. On the other hand, the effect of a short-sale constraint on the average bid-ask spread is ambiguous. Other models, including Miller (1977), predict short-sale constraints restrict pessimistic investors from trading on their beliefs, possibly reducing trading activity. Given the significance of short-sellers in today's markets, it seems intuitive that short-sale constraints could worsen market liquidity.

Empirical evidence, while limited, includes Alexander and Peterson (2008) and Diether, Lee and Werner (2009b), who use Reg SHO data to show that short-sale constraints (price tests) have a limited effect on market liquidity. A reduction in constraints increases short-sale activity, but both find that the restriction results in only slightly wider spreads. On the NYSE, both studies find an increase in short trading volume for pilot stocks. Furthermore, suspension of the up-tick rule is found to result in significantly wider spreads and thinner ask depths. Charoenrook and

Daouk (2005), in their study of market-wide short-sale restrictions, find that when short-selling is possible there is greater liquidity. Given the limited empirical literature, further evidence is required regarding the impact of short-selling on market liquidity.

2.4 Naked short-selling in equities markets

Despite the apparent assumption that naked short-selling is detrimental, relatively little or no empirical evidence is available on the impact of naked short-selling on financial markets. The literature discussed in the previous sections examines changes in the rules governing either covered short-sales (see *inter alia* Chang, Chang and Yu, 2007), or changes to short-sale constraints that affect both naked and covered short-sales (see *inter alia* Boehme, Danielsen and Sorescu, 2006). None of these studies explicitly examine naked short-selling or changes in short-sale constraints related to naked short-selling. This section reviews the limited literature which examines the impact of naked short-selling in equities markets.

Despite the widespread criticism, not all naked short-selling is abusive. Some naked short-selling occurs unintentionally when a short-seller locates shares to borrow (or has reasonable belief that shares can be located and borrowed), but subsequently is unable to borrow the stock in time for delivery. Further, some naked short-selling is due to market making. A fail to deliver (FTD) occurs when the seller of a security does not deliver that security to the buyer within the standard three-day settlement period (Boni, 2006). Naked short-selling is one way that this can occur. FTDs can also arise from various processing errors, delays in obtaining physical stock certificates or human error in entering the incorrect stock symbol. Boni (2006) provides an empirical description of delivery failures in US equity markets prior to Regulation SHO. The evidence is consistent with the hypothesis that pre-Regulation SHO, equity and options market-makers strategically failed to deliver shares that were expensive or impossible to borrow. The findings also support comments of equity and options market-makers that the inability to strategically fail to deliver shares post-Regulation SHO will reduce liquidity and increase short-sale constraints, particularly for stocks that are expensive to borrow. Consistently, Evans, Geczy, Musto and Reed (2009) document that the transactions of a major options market-maker reveal that in most hard-to-borrow situations, they choose not to borrow, and instead fail to deliver stock to its buyers.

Boulton and Braga-Alves (2010) look at the effect of the SEC's temporary restrictions on naked short-sales of 19 financial firms in 2008. They find that the restrictions are successful in eliminating naked short-sales for the restricted stocks, but naked short-sales increase dramatically for a closely matched sample of financial firms during the restricted period. Boulton and Braga-Alves (2010) proxy for naked short-sale activity using fail-to-deliver data obtained from the SEC. Consistent with Miller's (1977) overpricing hypothesis, they find evidence of a positive (negative) market reaction to the announcement (expiration) of the short-sale restrictions. Further, they document that the restrictions negatively impact various measures of liquidity, including bid-ask spreads and trading volume. Contrary to the notion that short-sale restrictions reduce volatility, they find no evidence of a volatility decrease during the restricted period. In fact, consistent with the theoretical models of Abreu and Brunnermeier (2002) and

Scheinkman and Xiong (2003), daily return volatility increased during the restricted period, albeit not significantly more than for a matched sample of financial firms.

In effect, Boulton and Braga-Alves (2010) provide the first empirical evidence regarding the impact of naked short-sale constraints. However, the study is limited to a sample of 19 financial firms over a period of only 17 trading days during which the market experienced heightened market volatility. Questions must be raised with respect to the applicability of the results to 'normal' periods of trading and to non-financial stocks. Further evidence is needed to corroborate the findings.

2.5 CDS markets

The previous sections of this chapter examine issues relating to the impact of short-selling in equities markets. Chapter 5 of this dissertation examines the impact of short-selling on CDS markets. Evidence regarding the relationship between short-selling and CDS markets is non-existent. Therefore this section surveys the existing literature on CDS markets. The CDS market is first described, as is literature relating to credit spread pricing, determinants of credit spreads, determinants of CDS spreads and other studies relating to CDS markets.

2.5.1 CDS market details

The market for credit derivatives has experienced spectacular growth in the last decade. According to the International Swap and Derivatives Association (ISDA), the notional value of outstanding CDSs increased from one to 62 trillion USD from 2001 to 2007. Prior to the ‘credit crisis’, the development of the CDS market was widely acknowledged as a source of substantial improvements in the financial system and the economy. Former US Federal Reserve Board Chairman Alan Greenspan observed that:

“The new instruments of risk dispersal have enabled the largest and most sophisticated banks, in their credit-granting role, to divest themselves of much credit risk by passing it to institutions with far less leverage...... These increasingly complex financial instruments have contributed to the development of a far more flexible, efficient, and hence resilient financial system than the one that existed just a quarter-century ago.”[18]

Ironically, CDS markets were a primary cause of the credit crisis and largely responsible for the collapse of Bear Stearns, AIG, WaMu and other mammoth corporations. According to top experts, CDSs were not only largely responsible for bringing down the American (and world) economy, but they still pose a substantial systemic risk. For example, Nobel prize-winning economist Myron Scholes said that over-the-counter CDSs are so dangerous that they should be “blown up or burned”, and we should start afresh. Another Nobel prize-winning economist, George Akerlof, predicted in 1993 that CDSs would cause the next meltdown.

[18] Comments by Alan Greenspan before the National Italian American Foundation in Washington, D.C. on October 12, 2005.

Single-name CDSs are the most liquid of the credit derivatives currently traded and form the basic building blocks for more complex structured credit products. A CDS is a contract between two parties, a protection buyer who makes fixed periodic payments, and a protection seller, who collects the premium in exchange for making the protection buyer whole in case of default. In general, trades are between institutional investors and dealers. CDSs are over-the-counter (OTC) transactions. They are similar to buying/selling insurance contracts on a corporation or sovereign entity's debt, without being regulated by insurance regulators (unlike insurance, it is not necessary to own the underlying debt to buy protection using CDSs). Before trading, institutional investors and dealers enter into an ISDA Master Agreement, setting up the legal framework for trading.

The premium paid by the protection buyer to the seller, often called 'spread', is quoted in basis points per annum of the contract's notional value and is usually paid quarterly. Note that these spreads are *not* the same type of concept as 'yield spread' of a corporate bond to a government bond. Rather, CDS spreads are the annual price of protection quoted in bps of the notional value, and not based on any risk-free bond or any benchmark interest rates. Periodic premium payments allow the protection buyer to deliver the defaulted bond at par or to receive the difference of par and the bond's recovery value. Therefore, a CDS is like a put option written on a corporate bond. Like a put option, the protection buyer is protected from losses incurred by a decline in the value of the bond as a result of a credit event. Accordingly, the CDS spread can be viewed as a premium on the put option, where payment of the premium is spread over the term of the contract. For example, the five-year CDS for Ford was quoted at 160 bps on April 27, 2004. Thus, if someone purchases the five-year protection for a

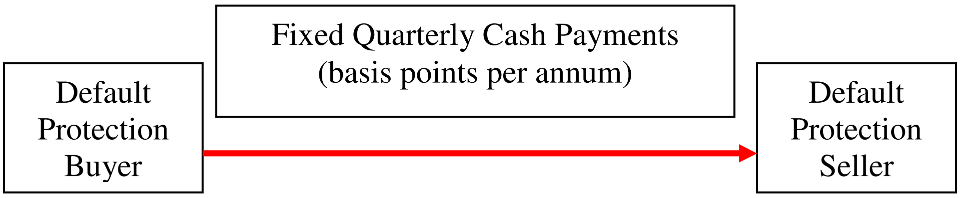
$10 million exposure to Ford credit, they would pay 40 bps, or $40,000, every quarter as an insurance premium for the protection received.

Each contract involves: a Reference Entity (the underlying entity on which one is buying/selling protection); a Reference Obligation (the bond or loan that is being 'insured'); a Term/Tenor, usually ranging from one to 10 years, with the five-year maturity the most common and liquid contracts; a Notional Principal, while there are no limits on the size or maturity of CDS contracts, though most contracts range between $10 million to $20 million in notional value; Credit Events (the specific events triggering the protection seller to pay the protection buyer – the defined events are bankruptcy, failure to pay, debt restructuring, and the rare obligation default, obligation acceleration, and repudiation/moratorium). Market participants generally view bankruptcy, failure to pay and restructuring as the most common. Bankruptcy, the clearest concept of all, is the reference entity's insolvency or inability to repay its debt. Failure-to-pay occurs when the reference entity, after a certain grace period, fails to make payment of principal or interest. Restructuring refers to a change in the terms of debt obligations that are adverse to the creditors. Restructuring is by far the most problematic of these trigger events, because 'adverse change' is an ambiguous concept. Accordingly, some market participants prefer to exclude the restructuring provision from a credit derivative contract altogether, or to restrict the scope of the provision.

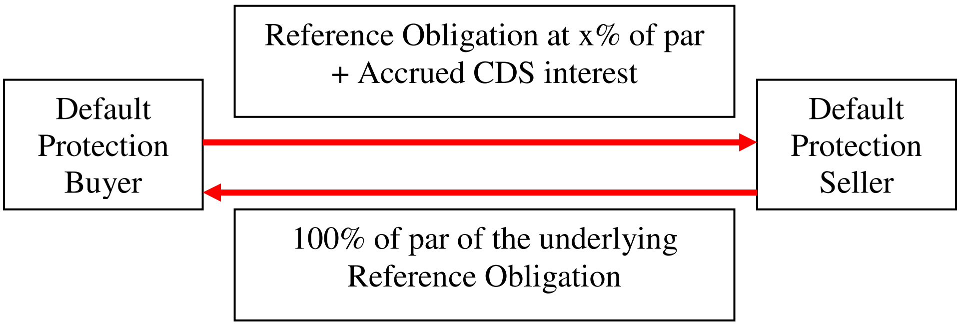
In the case of a credit event, under physical settlement the protection buyer has to deliver a bond of seniority at least equal to that of the reference obligation – if there are multiple bonds deliverable, the protection buyer will most likely deliver the cheapest bond to the protection seller. The life of a CDS from initiation of trade to maturity can be represented as follows:

Figure 2-1 CDS illustration

If there is no credit event:



In the case of a credit event:



The first step after a credit event occurs is the delivery of a 'Credit Event Notice', either by the protection buyer or the seller. Then, the compensation is to be paid by the protection seller to the buyer via either (1) physical settlement, or (2) cash settlement, as specified in the contract. In a physical settlement, the protection seller buys the distressed loan or bond from the protection buyer at par. Here the bond or loan purchased by the seller of protection is called the 'deliverable obligation'. Physical settlement is the most common form of settlement in the CDS market, and normally occurs within 30 days of the credit event. With cash settlement, the payment from the seller of protection to the protection buyer is determined as the difference between the notional value of the CDS and the final value of the reference obligation for the same notional value. Cash settlement is less common because obtaining quotes for the distressed reference credit is often difficult. A cash settlement typically occurs no later than five business days after the credit event.

CDSs can be used for a variety of reasons. Firstly, CDSs allow capital or credit exposure constrained businesses (banks for example) to free up capacity to facilitate more business. As it is easier to buy credit protection than short bonds, CDSs can be a short credit-positioning vehicle. CDSs may allow users to avoid triggering tax/accounting implications that arise from the sale of assets. CDSs also allow investors to speculate on deterioration or improvement of credit quality of a reference credit. CDSs also offer the opportunity to access hard-to-find credit (limited supply of bonds, small syndicate). Investors can tailor their credit exposure to maturity requirements, as well as desired seniority in capital structure. CDSs require no cash outlay and therefore create leverage. The standardised documentation, liquidity, ability to customise terms, and pure credit focus makes the CDS market a de facto standard for expressing a view on the credit market (either single credits, or baskets such as indices).

2.5.2 CDS pricing

Early methods of pricing CDS contracts involved more art than science. Today, however, pricing is more quantitatively based, using parameters such as, (1) the likelihood of default, (2) the recovery rate when default occurs, and (3) some consideration for liquidity, regulatory, and market sentiment about the credit. In theory, CDS spreads should be closely related to bond yield spreads, or excess yields to risk-free government bonds. To elaborate, consider two portfolios; the first consists of (1) a short position (*i.e.* selling protection) in the CDS of a company and (2) a long position in a risk-free bond; the second consists of an outright long position in the company's corporate bond, all with the same maturity and par and notional values of \$100. Theoretically, these two investments should provide identical returns, resulting in the CDS spread equalling the corporate bond spread (see Duffie, 1999).

If no default occurs, principal payoff at maturity of the portfolio of a CDS and a risk-free bond will be \$100, as no payment is made on the CDS short position and a risk-free bond pays \$100. The corporate bond will also pay \$100, if no default occurs. However, if default occurs, the portfolio of a CDS and a risk-free bond will pay the amount equal to \$100 minus the contingent payment on the CDS upon default. This payment depends on the recovery rate of the defaulted corporate bond. If it is assumed, for example, that the recovery rate is 45%, the protection seller must pay \$55, or 55%, on \$100 notional. Using the same recovery rate, the investment in the corporate bond would also result in a payoff value of \$55 upon default. These two investments have identical payoffs and risk profiles. Accordingly, the CDS and the corporate bond should be traded at the same spread level. In pricing a CDS, one must know, or make assumptions about, the likelihood of default over the term of the swap, the recovery rate, and discount factors (or the yield curve). Given CDS spreads should be intricately linked to credit spreads, the pricing models should also be intricately linked. This section reviews the literature on the theoretical approaches to pricing credit-sensitive instruments.

Credit risk models are usually divided into structural and reduced-form models. Under structural form models, the liabilities of a firm are seen as a contingent claim on the assets of the firm itself and default occurs when the market value of the assets, which is modelled as a stochastic process, reaches some limit. This approach, developed by Black and Scholes (1973) and Merton (1974), uses structural models to connect the price of credit-sensitive instruments directly to the economic determinants of financial distress and loss, given default. Structural models imply that the main determinants of the likelihood and severity of default are financial leverage, volatility, and the risk-free term structure.

The reduced-form approach, instead, postulates that default occurs randomly, due to some exogenous factor(s) whose probability of occurring, dubbed the 'intensity', is modelled and calibrated using market data. Models belonging to this latter class are also called intensity-based models. Reduced-form models, developed by Litterman and Iben (1991), Jarrow and Turnbull (1995) and Jarrow, Landow and Turnbull (1997), use market data to recover the parameters needed to value credit-sensitive claims. Duffie (1999), Houweling and Vorst (2002), and Hull and White (2000) apply reduced-form models to credit derivatives. Reduced-form models are praised by practitioners because of their capacity, by construction, to fit market data, but structural models are usually viewed by academics as being more appropriate for analysing the determinants of credit risk.

The first structural model on credit risk was introduced by Merton (1974). In this model, default occurs when the market value of the firm, which is assumed to be described by a random process, is below the face value of the outstanding debt at the maturity of the debt itself. In this case, the shareholders give the assets of the firm up to the bondholders. Merton's intuition was that a bond subject to credit risk can be seen as a combination of a long position in a risk-free bond and short position in a European put option sold to the shareholders with a strike price equal to the face value of the risky bond. In this setting, the price of the risky bond can be determined through standard option pricing methods which link its value to the parameters of the stochastic process driving the firm value and to the level of outstanding debt. The prediction of the Merton model is that credit spreads should be a function of the risk-free interest rate, nominal outstanding amount of debt, firm value and asset volatility. Hence, structural models generate predictions for what the theoretical determinants of credit spread changes should be, and offer a prediction for whether changes in these variables should be positively or negatively correlated with changes in credit spreads.

The intuition behind these predictions is as follows. Firstly, the risk-free interest rate represents the drift of the process describing the value of the assets of the firm under the risk-neutral measure. Higher interest rates increase the future expected value of the assets, thus reducing credit spreads. The nominal value of the debt represents the threshold at which default is triggered. A higher amount of debt makes default more likely, so that higher credit spreads are expected. Higher values for the assets of the firm make the regular payment of the debt more likely and credit spreads are expected to be lower. Higher asset volatility increases the value of the put option granted to the shareholders, thus increasing the compensation required by the bondholders through higher credit spreads.

2.5.3 Credit spread determinants

The aim of the Merton model and other structural models is to explain the percentage of bond spreads which arise from credit risk using a small number of factors, including those just described. However, there are other factors not linked to credit risk that are shown to be an important component of bond spreads. Empirical applications of structural models incorporate the predictions of the models and attempt to capture additional explanatory variables which explain credit spreads. These studies attempt to explain credit spreads by regressing observed spreads levels on factors that theoretical models suggest are relevant in determining both default and non-default components of credit spreads.

Collin-Dufresne, Goldstein and Martin (2001) initiate this strand of research by using the structural approach to identify the theoretical determinants of corporate bond credit spreads. These variables are then used as explanatory variables in regressions for changes in corporate credit spreads, rather than inputs to a particular structural model. Collin-Dufresne, Goldstein and Martin (2001) find that the explanatory power of the theoretical variables is modest (regression analysis can only explain about 25% of the observed credit spread changes), and that a significant part of the residuals is driven by a common systematic factor that is not captured by the theoretical variables. They conclude that bond spread changes are mostly driven by supply and demand shocks which are specific to the corporate bond market and independent of both default and liquidity factors.

Campbell and Taksler (2003) extend this analysis using regressions for levels of the corporate bond spread, rather than changes in corporate credit spreads. Campbell and Taksler (2003) focus on the effect of equity volatility on corporate bond yields and document that firm specific equity volatility is an important determinant of credit spreads, and that the economic effects of volatility are large. More recently, Avramov, Jostova and Philipov (2007) provide new evidence on the empirical success of structural models in explaining changes in corporate credit risk. Using a set of common factors and company-level fundamentals, inspired by structural models, they are able to explain more than 54% (67%) of the variation in credit spread changes for medium-grade (low-grade) bonds, with no clearly dominant latent factor left in the unexplained variation. Cremers, Driessen, Maenhout and Weinbaum (2008) introduce measures of volatility and jump risks that are based on individual stock options to explain bond spreads. They show that implied volatilities of individual options contain useful information for credit spreads, and improve on historical volatilities when explaining the cross-sectional and time-series variations in a panel of corporate bond spreads.

2.5.4 CDS determinants

The previous literature focuses on corporate bond spreads, i.e., the difference between the corporate bond yield and the risk-free rate. However, more recent studies (see *inter alia* Benkert, 2004, Greatrex, 2009, Ericsson, Jacobs and Oviedo, 2009, and Zhang, Zhou and Zhu, 2009) focus on the relationship between CDS spreads and key variables suggested by economic theory. Thus, while the main focus of these more recent papers remains credit risk, an important distinction is the use of CDS spreads rather than corporate bond spreads as the variable of interest.

Ericsson, Jacobs and Oviedo (2009) advocate the use CDS spreads in preference to bond spreads for a number of reasons. While economically comparable to bond spreads, CDS spreads do not require the specification of a benchmark risk-free yield curve, as they are already quoted as spreads. This avoids undue noise which may arise from the use of a misspecified model of the risk-free yield curve. The choice of the risk-free yield curve includes the choice of a reference risk-free asset, which can be problematic (see Houweling and Vorst, 2005), but also the choice of a framework to remove coupon effects.

CDS spreads could reflect changes in credit risk more accurately and quickly than corporate bond yield spreads. Blanco, Brennan and Marsh (2005) show that a change in the credit quality of the underlying entity is more likely to be reflected in the CDS spread before the bond yield spread. This could be due to important non-default components in bond spreads that obscure the impact of changes in credit quality. Longstaff, Mithal and Neis (2005) document the existence of an illiquidity component in bond yield spreads. Related to this, trading in CDS markets has increased, while many corporate bonds are rarely traded. Partly as a result, CDS data is collected at a daily frequency, while many studies that use corporate bonds typically use observations at a monthly frequency; the greater sampling frequency should allow for cleaner tests.

The previous literature in this area uses a range of theoretical determinants of default risk to model CDS spreads. Skinner and Townsend (2002) present the first empirical examination of credit default swaps. Using a limited sample of 43 sovereign USD default swap trades from September 1997 to February 1999, they suggest a regression model based on the idea that CDSs can be viewed as a put option. By viewing a CDS as a put option, they are able to determine the main factors that must be considered in valuing credit default swaps. They document that four of the five standard factors that are important in pricing exchange traded put options, namely, the risk-free rate, volatility, underlying asset, and time to maturity, are statistically significant factors for pricing CDSs as well. Importantly, variables that are external to the CDS agreement tend to be statistically significant and are of the correct sign. However, the variables that are determined by the CDS agreement, namely, the time to maturity and the exercise price, are of the ‘‘incorrect’’ sign according to financial theory.

Accordingly, empirical studies examine many factors that are external to the CDS agreement. Benkert (2004), using a larger panel data set of CDSs on 120 international firms from 1999 to 2002, investigates the effects of historical and option-implied equity volatilities on CDS premia, thus extending the idea proposed by Campbell and Taksler (2003) in the context of corporate bond yields. Consistent with Campbell and Taksler (2003), he documents that option-implied volatility is a more important factor in explaining variation in CDS premia than historical volatility.

Abid and Naifar (2006) empirically examine the determinants of CDS rates using 207 trades during the period from 15 May, 2000 to 15 May, 2001. The trades are composed of 73 underlying default swaps listed across 11 European markets. They document that the majority of variables, detected from the credit risk pricing theories, explain more than 60% of the total level of CDS spreads. These theoretical variables are credit rating, maturity, risk-free interest rate, slope of the yield curve and volatility of equities. Importantly, credit rating is the most important determinant of CDS rates. Abid and Naifar (2006) argue this result is justified because the rating agencies examine many issues in their analysis, including the financial position of the firm, firm-specific issues such as the quality of management, the survey of the industry as a whole and competition of the firm. Abid and Naifar (2006) highlight that liquidity is an important issue in the corporate bond market and suggest using proxies for liquidity to explain CDS prices.

Accordingly, Fabozzi, Cheng and Chen (2007) examine the determinants of CDS spreads, focusing on the effect of liquidity factors. In the bond market, higher liquidity usually requires less compensation, and therefore a lower yield spread (Longstaff, Mithal and Neis, 2005). However, a CDS has different economic characteristics from a bond in that a swap is a contract in which the value of the protection is paid in instalments, while a bond demands the credit risk to be paid up front. Due to this contractual difference, the liquidity penalty (premium or discount) may be reflected differently in their prices. They examine two liquidity factors (the bid–ask spread and the number of transactions) using a sample of CDS spreads from 1,372 reference entities during the period of February 2000 to April 2003. The results support the position that liquidity factors have a very significant effect on CDS spreads. The findings suggest that CDSs which trade with greater liquidity have a higher CDS spread. This is contrary to the results in the bond market where investors require an additional premium as compensation for illiquidity in the CDS market.

Fabozzi, Cheng and Chen (2007) attribute the contrasting results to the difference in the economic characteristics of a CDS contract versus a bond.

While not examined in their study, Abid and Naifar (2006) also suggest that firm-specific ratios suggested by structural models, such as profitability and leverage, may be significant in exploring the determinants of CDS spreads. Greatrex (2009) is among the first studies to incorporate this notion, and examines a CDS data set covering 333 firms over a five-year period spanning January 2001 to March 2006. Greatrex (2009) examines changes in CDS spreads, as opposed to levels, because stationary tests find CDS spreads to be non-stationary, while spread changes are stationary. The findings indicate that the variables suggested by structural models are able to explain 30% of the variation in CDS spread changes. A rating-based CDS index that accounts for both credit risk and overall market conditions is the single best predictor of CDS spread changes. Leverage and volatility, however, are also key determinants, as these two variables can explain almost half of the explained variation in monthly CDS spread changes.

Ericsson, Jacobs and Oviedo (2009) also estimate linear regressions on the relationship between CDS spreads and key variables suggested by economic theory. Using a sample period from 1999 to 2002, they conduct both level regressions and difference regressions. They find that firm leverage, volatility and the riskless interest rate are statistically significant, and that their effect is economically important as well as intuitively plausible. The explanatory power of these theoretical variables for spread levels is approximately 60%, and the explanatory power for spread differences is approximately 23%. Interestingly, a negative correlation between spreads and the risk-free rate is documented which is consistent with the implication of structural models that an increase in the risk-free rate will decrease risk-adjusted default probabilities

Zhang, Zhou and Zhu (2009) propose a novel empirical approach to explain credit spread variation, using volatility and jump-risk measures constructed from high-frequency equity return data. The data analysed includes CDS quotes written on 307 US entities (excluding sovereign entities) over the period January 2001 to December 2003. They conduct regressions with the jump and volatility measures, and also include other control variables including ratings, macro financial variables, and balance sheet information as predicted by the structural models (and as evidenced by the empirical literature). The empirical findings suggest that long-run historical volatility, short-run realised volatility, and various jump-risk measures all have statistically significant and economically meaningful effects on credit spreads. Realised jump measures explain 19% of total variations in the level of credit spreads, while measures of the historical skewness and historical kurtosis of jump risk explain only 3%. Notably, volatility and jump risks alone can predict 53% of the CDS spread variations. The explanatory power of credit spread changes from various structural variables is much lower, confirming the finding in Collin-Dufresne, Goldstein and Martin (2001). Nevertheless, including the short-run realised volatility can lead to a significant improvement in the change regressions.

While Ericsson, Jacobs and Oviedo (2009) and Zhang, Zhou and Zhu (2009) demonstrate a strong relation between CDS spreads and equity historical volatilities, Cao, Yu and Zhong (2010) focus on the relation between CDS spreads and options market information and show that option-implied volatility is an even more important determinant of CDS spreads than historical volatility. Cao, Yu and Zhong (2010) investigate whether put option-implied volatility is an important determinant of CDS pricing. This is motivated by the view that CDSs are similar to out-of-the-money put options in that both offer a low cost and effective protection against downside risk. Using a sample of 301 firms with both CDS and options data during the period January 2001 to December 2006, they estimate firm-level time-series regressions of the CDS spread on implied volatility and historical volatility, controlling for other determinants of credit spreads used in the literature. Results indicate that implied volatility dominates historical volatility in explaining the time-series variation of CDS spreads, and that this result is robust to the horizon of the historical volatility estimator.

Overall, the literature documents that individual firm CDS prices are related to risk-free interest rates, share prices, equity volatility, bond ratings and firm leverage. These studies suggest that theoretical determinants of default risk explain a significant amount of variation in CDS prices. Other studies incorporate new determinants to better explain the variation in CDS spreads. Zhang, Zhou and Zhu (2009) use theoretical determinants along with volatility and jump risk of individual firms from high-frequency equity prices to explain variation in CDS spreads. Cao, Yu and Zhong (2010) find that individual firms' put option-implied volatility is superior to historical volatility in explaining variation in CDS spreads. Fabozzi, Cheng and Chen (2007) find that measures of CDS liquidity are significant in explaining variation in CDS spreads.

This dissertation extends this work by proposing a new measure of the likelihood of firm default - short-selling. As discussed above, empirical evidence suggests that short-sellers are informed traders who take positions by selling a company's stock in the expectation that prices will fall in the near future following the revelation of bad news specific to that firm (see *inter alia* Diether Lee and Werner, 2009a and Boehmer, Jones and Zhang, 2008). As such, the level of short-selling is a direct measure of the prospects for a company. High (low) short-selling indicates a more (less) pessimistic view of a company and an increased (decreased) likelihood of default. Therefore, CDS spreads should exhibit a positive and significant relationship to the level of short-selling. By examining the relationship between CDS spreads and short-selling, this dissertation adds to the existing literature which examines the determinants of CDS spreads and also adds to the existing literature on the information content of short-selling.

2.5.5 Other studies using CDS spreads

With the proliferation of CDS markets and the continual improvement in the availability of data pertaining to the CDS market, many studies utilise CDS spreads for various purposes. Houweling and Vorst (2005) implement a set of simple reduced-form models on market swap quotes and corporate bond quotes to compare market prices of CDSs with model prices. The results show that a simple reduced-form model outperforms directly comparing bonds' credit spreads to default swap premiums. Importantly, the model yields unbiased premium estimates for default swaps on investment grade issuers, but only if the swap or repo rates are used as a proxy for default-free interest rates. This indicates that the government curve is no longer seen as the reference default-free curve. Longstaff, Mithal and Neis (2005) document the differences between default swap spreads and corporate bond yield spreads, using various risk-free benchmarks. Under the assumption that default swap spreads do not contain a liquidity component, the differences between the spreads highlight the relative importance of default risk and liquidity for corporate bonds.

Blanco, Brennan and Marsh (2005) utilise the CDS market to test the theoretical equivalence of CDS prices and credit spreads derived by Duffie (1999), finding support for the parity relation as an equilibrium condition. Their results also suggest that CDS spreads contain useful information in that CDS prices lead in the price discovery process over credit spreads. Blanco, Brennan and Marsh (2005) argue that, combined with the fact that CDS spreads are a cleaner indicator than bond spreads, the findings suggest that CDS prices are useful indicators for analysts interested in measuring credit risk. Credit risk concerns almost all financial activities and, by definition, should be reflected in the market prices of different credit-sensitive claims including CDS spreads, bonds and stocks. Given these assets are traded in structurally different markets, differences may exist in the relative speed with which respective markets respond to the changes in credit conditions. Following Blanco, Brennan and Marsh (2005), various studies examine the relationship between CDS, stock and bond markets to determine where the price discovery of credit risk occurs first.

Blanco, Brennan and Marsh (2005) consider a Vector Error Correction Model (VECM) for explaining changes in bond and CDS spreads. Using a sample of 33 North American and European firms, they conclude that the CDS market leads the bond market. In a similar vein, Zhu (2004, 2006) studies an international sample of 24 issuers. Using a Granger causality test, the results indicate that the CDS market and the bond market are equally important in the incorporation of new information about the credit risk of companies. However, when a VECM is used to examine the price discovery process, results change, supporting the leading role of the CDS market. Norden and Weber (2004) apply traditional event study methodology to examine whether (and how) stock and CDS markets respond to ratings announcements during the years 2000 to 2002. The findings reveal that both markets anticipate not only rating downgrades, but also reviews for downgrade by all agencies if taken separately. Further, both markets do not exhibit any significant response to positive ratings events. Norden and Weber (2004) examine only CDS and stock markets, and conclude that neither market leads in the price discovery process.

Longstaff, Mithal and Neis (2005) use a Vector Auto-Regressive model (VAR) to investigate the lead-lag relationships between changes in CDS spreads, changes in bond spreads, and stock returns. Using a sample of 68 North American companies, they conclude that information flows first into the CDS and stock markets, and then into the bond market. Norden and Weber (2005) use the same VAR representation to analyse the co-movement of CDS, bond and stock markets, considering an international sample of 58 companies. For the specific case of CDS and bond markets, they also perform a price discovery analysis using a VECM, consistent with Blanco, Brennan and Marsh (2005) and with Zhu (2004, 2006). Norden and Weber's (2005) results support the idea that the stock market leads the CDS and bond markets. Their evidence also supports the leading role of the CDS market with respect to the bond market. Forte and Peña (2009), on the basis of VECM framework and stock market implied credit spreads, corroborate the finding that the stock market leads the CDS and bond market more frequently than vice versa. They also confirm the leading role of the CDS market with respect to the bond market.

Chapter 3: Short-sale constraints and market quality: Evidence from the 2008 short-sale bans

3.1 Introduction

The literature review examining the impact of short-selling in Chapter 2 highlights a dearth of empirical research in several areas of the literature. While short-selling has long been a contentious issue, relatively little or no empirical evidence is available on the impact of short-sale restrictions on market quality. The 2008 short-sale bans provide an ideal setting for these tests because it provides a binding constraint. Thus, it is not necessary to rely on proxies for short-sale constraints, as in previous research. The purpose of this chapter is to empirically examine the impact of the 2008 short-selling bans on the market quality of stocks subject to the bans. Thus, in doing so this chapter also examines whether the short-selling bans achieved their desired outcome. Data from 14 equity markets around the world is employed to examine market quality in terms of abnormal returns, stock price volatility, bid-ask spreads and trading volume.

The relationship between short-sales and stock return volatility is a contentious issue and has received limited academic attention. Further, evidence on short-sale constraints and liquidity is relatively limited. This chapter adds to the limited evidence of the impact of short-sale constraints on liquidity, in addition to examining the impact of short-sale constraints on returns and volatility. The remainder of this chapter is organised as follows. Section 3.2 uses the literature on short-sale constraints to develop a set of testable hypotheses. Section 3.3 provides a review of the short-sale bans and Section 3.4 describes the data and methodology used in this chapter. Section 3.5 reports the empirical analysis of the impact of the bans on returns, liquidity and stock price volatility. Section 3.6 provides a summary of the main results and concludes the chapter.

3.2 Hypothesis development

This section uses the literature reviewed in Section 2 to develop several hypotheses that are tested in this chapter. The disagreement models (e.g., Miller 1977) predict that short-selling bans prevent at least some pessimists from taking a bearish position in a financial stock. Thus, short-selling bans should cause prices of affected stocks to rise, leading to overvaluation relative to fundamentals. Empirical evidence is consistent with this notion and suggests a high level of short-selling is followed by negative abnormal returns and short-selling restrictions are related to positive abnormal returns (see *inter alia* Chang, Chang and Yu 2007). However, while the empirical evidence is unambiguous, there are various conflicting factors that could affect the magnitude of the results surrounding the 2008 short-selling bans. Therefore the following hypothesis is tested:

Hypothesis$_{3,1}$: *Stocks experience positive abnormal returns when the short-selling ban is imposed.*

As discussed in Section 2.3.1, the relationship between short-sales and stock return volatility is a contentious issue and has received limited academic attention. While theoretical models attempt to explain the volatility of stock returns when short-sale constraints are imposed, the theory is divided on how short-sale constraints affect the volatility of market returns.

Hong and Stein (2003) develop a heterogeneous agent model linking short-sale constraints to market crashes. In their model, if certain investors are constrained from selling short, their accumulated unrevealed negative information will not be impounded until the market begins to fall, which further aggravates a market decline and leads to a crash. Therefore, their model predicts a higher frequency of extreme negative stock returns when short-sale constraints are binding. Scheinkman and Xiong (2003) predict a significant decrease in trading volume and price volatility when short-sale constraints are lifted. Consistent with Scheinkman and Xiong (2003), Abreu and Brunnermeier (2002, 2003) document that short-sale constraints can be a direct cause of, or at least a necessary condition for, bubbles and excessive volatility. Bai, Chang and Wang (2006) predict higher price volatility when short-selling is restricted, as better informed investors are held out of the market, and less informed investors perceive the risk as considerably higher.

While the above theoretical evidence suggests that short-sale constraints have an adverse effect on volatility, Allen and Gale (1991) provide an exception to this view.

Allen and Gale (1991) predict that without the presence of short-sale constraints, financial innovation is not necessarily efficient and renders short-selling a destabilising influence in the economy. Bernardo and Welch (2004) develop a model that shows how the fear of financial crisis, instead of a real liquidity shock, is the true cause of financial crises. One implication of their model is that constraints which hinder market participants from front-running other investors can effectively prevent financial crises from happening, which is consistent with the finding of Allen and Gale (1991) that short-sales can potentially destabilise the economy.

Overall, the theoretical evidence provides conflicting predictions regarding the impact of short-sales on volatility. Thus the following hypothesis is tested:

Hypothesis$_{3,2}$: *Stock price volatility increases in the banned stocks when the short-selling ban is imposed.*

Diamond and Verrecchia (1987) predict wider bid-ask spreads when short-selling is restricted. This is due to the exclusion of traders that are willing to trade on their negative views but are prevented due to short-selling constraints. Other models including Miller (1977) predict short-sale constraints restrict pessimistic investors from trading on their beliefs, possibly reducing trading activity. Given the extent of short-selling, this suggests that a short-selling ban could worsen market liquidity in terms of both trading activity and bid-ask spreads. Given the limited empirical literature, further evidence is required regarding the impact of short-selling on market liquidity. Therefore the following two hypotheses are tested:

Hypothesis$_{3,3}$: *Bid-ask spreads widen in the banned stocks when the short-selling ban is imposed.*

Hypothesis$_{3,4}$: *Trading volume decreases in the banned stocks when the short-selling ban is imposed.*

3.3 Review of short-sale bans

This section provides a brief review of regulations implemented by regulators in response to the actions of the UK FSA and US SEC. On September 18, 2008, the FSA banned short-selling (naked and covered) in financial stocks in response to the financial turmoil of the global economy. The temporary ban, effective from September 19, 2008 to January 16, 2009, covered the creation and increase of net short positions in 29 financial stocks on the London Stock Exchange. Later that day, the SEC imposed a similar ban on more than 800 financial stocks in the US market which was later amended on 21 September, 2008 and was set to expire at 23:59 ET on 2 October, 2008.[19] This was followed in Canada by the Ontario Securities Commission (OSC) prohibiting the short-selling of specified financial issuers listed on the Toronto Stock Exchange (TSX) that are also interlisted in the US. In Switzerland, the Swiss Federal Banking Commission (SFBC), SWX and SWX Europe placed prohibitions on short-selling, coming into effect on 19 September, 2008. The SFBC and SWX prohibition applied to naked short-selling in all securities,

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[19] The ban included exemptions for options market makers when selling short as part of bona fide market making and hedging activities.

while the SWX Europe prohibition applied to covered short-sales in certain financial stocks.

Overnight and over the weekend many other markets worldwide announced bans which came into effect 22 September, 2008 including: Australia, where the Australian Securities and Investments Commission (ASIC) banned all forms of short-selling in all stocks; and Belgium, France, Luxembourg, The Netherlands, Portugal and Germany prohibiting naked short-selling for specified financial institutions. The next day, 23 September, 2008, the Italian regulator, Commissione Nazionale per le Società e la Borsa (CONSOB), placed a similar ban on naked short-selling of shares issued by banks and insurance companies. Over the next few days no further bans were enforced but many regulators clarified and adjusted their stance on short-selling. Russia and Korea were the next markets to make changes, both placing a prohibition on the short-selling of all securities, effective 30 September, 2008 and 1 October, 2008, respectively.

On October 2, 2008, the SEC extended the U.S ban to the earlier of October 17, 2008 or three business days following enactment of the Troubled Asset Relief Program (TARP, formally known as HR 1424, the Emergency Economic Stabilization Act of 2008). TARP was subsequently enacted on October 3, 2008 and the SEC announced that the ban would expire at 11:59pm ET on October 8, 2008. As of October 9, short-selling was again permitted in all stocks, provided market participants complied with the requirement to borrow shares in advance, as mandated by the naked short-selling ban (which continued).[20] The Canadian regulators also removed short-selling prohibitions on 8 October, 2008.

While some bans were being lifted other markets were still to enforce bans, including: the Financial Supervisory Authority of Iceland prohibiting the short-selling of financial instruments in six banks and insurers on 6 October, 2008; the Financial Supervisory Authority of Norway, Kredittilsynet, banning short-selling in financial equities on 8 October, 2008; the Danish Financial Supervisory Authority prohibiting short-selling in all Danish banks with effect from 13 October, 2008; and in Greece, the Capital Markets Commission banning short-sales in all stocks on 10 October, 2008.

Other markets began revising bans, including Australia, where ASIC announced on 21 October, 2008 that it expected to lift the ban on covered short-selling of non-financial stocks from 19 November, 2008. This was followed by further prohibitions, including: Austria, where the FMA prohibited naked short-selling of four financial companies with effect from 28 October, 2008; Italy where on 10 October, 2008, the Italian regulator (CONSOB) extended its ban on short-selling to cover all stocks; Japan where on 27 October, 2008, the Financial Services Agency of Japan (FSA) announced a ban on naked short-selling of all stocks effective from 29 October, 2008. In Italy, the short-selling prohibition was lifted for non-financials on 30 December, 2008 and remained in place for financials along with the ban on naked short-selling on all stocks.

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[20] The SEC naked short-selling ban was introduced on 17 September, 2008, and restricted the naked short-selling of all US stocks, effective 18 September, 2008.

As markets worldwide began to stabilise, other markets started to lift existing bans, including: the UK, which lifted its ban on the short-selling of financial stocks on 16 January, 2009; SWX Europe on 16 January, 2009; Australia, where ASIC announced the expiry of its ban on covered short-selling of financial securities as of 25 May, 2009; Italy, where on 31 May, 2009 the prohibition was amended to allow covered short-selling in banks and insurance companies; Greece, where the Hellenic Capital Market Commission announced that short-selling of stocks listed on the Athens Exchange was permitted again from 1 June, 2009; the Netherlands, which also lifted its prohibition on short-selling, as of 1 June, 2009, and South Korea, which lifted its ban on short-selling of non-financial company stocks on 1 June, 2009.

3.4 Data and method

Reuters data provided by the Securities Industry Research Centre of Asia Pacific (SIRCA) is obtained to examine the impact of the 2008 short-selling bans on the market quality of banned stocks. The data is sampled at a daily level over the period January 1, 2007 to December 31, 2008. Table 3-1 documents 25 markets that experienced some form of short-selling ban during 2008. Due to data limitations, certain markets are excluded from the analysis, including Austria, Denmark, Iceland, Ireland and Luxembourg. Other markets are removed because short-selling bans applied to all listed stocks, leaving no suitable control sample (Australia, Greece, Russia, Korea, Pakistan and Switzerland (SWX and SFBC)). This left 11 markets that imposed a ban on the short-selling of a restricted group of stocks (usually financial stocks). Of these 11 markets, five imposed a covered short-selling ban (US, UK, Canada, Switzerland (SWX Europe) and Norway) and the remaining six markets imposed a ban on naked short-selling (The Netherlands, Belgium, France, Germany, Italy and Portugal).

For robustness, data from Japan, Sweden and Hong Kong is collected. These markets are used as there were no bans placed on stocks over the same period as the US short-selling bans. Financial stocks in these markets are employed as a treatment sample over the same period as the US ban to provide an indication of changes in market quality in markets with no bans imposed. Therefore there are three distinct groups representing different levels of short-selling constraints. The first group with tight restrictions imposed (short-selling ban on financials), the second group with less restrictive bans imposed (naked short-selling ban on financials) and the third group with no bans imposed.

Table 3-1 Short-sale bans around the world

For each market the table describes whether the short-sale ban applied to all forms of short-sales (covered and naked) or naked short-sales only, the stocks to which the ban applied and the date when the ban was imposed and lifted (if applicable). ALL indicates the ban applies to all stocks listed. FINS indicates the ban applies to securities issued by financial institutions.

	Short-Sale ban			Naked short-sale ban		
Market	Covers	Start date	End date	Covers	Start date	End date
Australia	ALL	22/09/08	19/11/08	ALL	22/09/08	Indefinite
Australia	FINS	22/09/08	25/05/09			
United States	FINS	19/09/08	08/10/08	ALL	18/07/08	Indefinite
United Kingdom	FINS	19/09/08	16/01/09			
Canada	FINS	19/09/08	08/10/08			
Ireland	FINS	19/09/08	Indefinite			
Greece	ALL	10/10/08	31/05/09			
Switzerland (SWX Europe)	FINS	19/09/08	16/01/09			
Norway	FINS	08/10/08	Indefinite			
Denmark	FINS	13/10/08	Indefinite			
Korea	ALL	01/10/08	01/06/09			
Korea	FINS	01/10/08	Indefinite			
Russia	ALL	30/09/08	Indefinite			
Pakistan	ALL	24/09/08	Indefinite			
Netherlands				FINS	22/09/08	01/06/09
Iceland				FINS	06/10/08	Indefinite
Germany				FINS	20/09/08	01/01/10
Austria				FINS	28/10/08	30/09/09
Portugal				FINS	22/09/08	Indefinite
Italy				FINS	23/09/08	31/07/09
Netherlands				FINS	22/09/08	05/10/08
France				FINS	22/09/08	Indefinite
Belgium				FINS	22/09/08	21/09/09
Switzerland (SWX & SFBC)				ALL	19/09/08	Indefinite
Japan				ALL	28/10/08	Indefinite
Luxembourg				FINS	22/09/08	Indefinite

To test for changes in abnormal returns, cumulative abnormal returns for each market around their respective event dates are calculated. Brown and Warner (1985) find that the market model and market-adjusted model perform well under a number of circumstances and perform better than more complex methods. Thus, cumulative abnormal returns (CARs) are calculated using the market-adjusted model and the market model, defined as:

$$CAR_i^a(t_1, t_2) = \sum_{t=t_1}^{t_2} (R_{it} - R_{Mt}), \tag{3.1}$$

$$CAR_i^m(t_1, t_2) = \sum_{t=t_1}^{t_2} \left[R_{it} - \left(\hat{\alpha}_i + \hat{\beta}_i R_{Mt} \right) \right], \tag{3.2}$$

where R_{it} is stock i's return on day t, and R_{Mt} is the equal weighted return on a portfolio of stocks in the control sample (described below) from the corresponding market on day t (see Table 3-2 for a list of control samples). The coefficients $\hat{\alpha}_i$ and $\hat{\beta}_i$ are estimates of the intercept and slope coefficients in the OLS market model when R_{it} is regressed on R_{Mt} in the pre-event estimation window. The estimation window begins 1 July, 2007 and ends 31 August, 2008. To test for significance, both a parametric t-test and non-parametric Wilcoxon sign-rank test is employed.

To examine changes in market quality measures before and during the short-selling ban, 30 trading days prior (subsequent) to the short-selling ban is selected as the pre-event period (post-event period). If the ban was in place for less than 30 trading days the duration of the ban is used as the post-event window. Any changes documented could be driven by market-wide factors or different shocks affecting the market. To control for these potential effects, a control sample is constructed which includes stocks from a major index in the corresponding market not affected by the short-selling restrictions. Table 3-2 lists each market and the corresponding control sample used. For example, in the US, the NYSE composite index, which covers all stocks listed on the NYSE, is used. From the NYSE composite index, stocks subject to the ban are removed and the 300 largest remaining stocks (by market capitalisation) are used as the control sample.

To examine whether market quality measures change for treatment stocks relative to control stocks, summary statistics of the pre- and post-event averages for each variable are examined. The percentage difference between the pre- and post-event averages for each variable (labelled Difference) in both the treatment and control sample is then calculated. Next, the difference of the difference between the treatment and control sample (labelled Difference-in-difference) is calculated. To test for statistical significance and to control for other possible confounding factors, the treatment and control samples are pooled together to estimate the following cross-sectional regressions for each market for each day in the pre- and post-event period surrounding each event:

$$Y_{it} = \beta_{0t} + \beta_{1t}\, Period_i + \beta_{2t}\, Sample_i + \beta_{3t}\, Ban_i + \varepsilon_{it} \qquad (3.3)$$

where Y_{it} is the average measure of interest for stock i during interval t.[21] Ban_i is a dummy variable equal to one if the stocks are subject to a short-selling ban, and zero otherwise. $Period_i$ is a control dummy variable equal to one if the observation lies in the post-event period, and zero otherwise. $Sample_i$ is a control dummy variable equal to one if the observation belongs to the treatment sample, and zero otherwise. To control for variation between stocks and dates, calendar day-fixed effects and stock-fixed effects are included in the pooled regressions (Diether, Lee and Werner, 2009a). To address concerns over serial correlation and cross-correlation, standard errors are calculated that cluster by both calendar date and stock (Thompson, 2009).

To test the impact of the short-selling bans on market quality, volatility and liquidity measures are examined. Volatility is examined using a price volatility and return volatility measure. Price volatility is measured as the ln (daily high / daily low). Return volatility is measured as [ln (closing price on day t / closing price on day t-1)] ^{2}. To examine the impact on liquidity, three measures are examined. The first is the relative bid-ask spread, calculated as the quoted closing bid-ask spread (difference between prevailing best bid and ask quotes), divided by the prevailing quoted closing midpoint. Relative bid-ask spreads are used, as they control for stock price variation, both over time and across stocks. Trading volume and Turnover value are also examined, measured as total daily volume traded and the currency value of traded daily volume, respectively.

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[21] Initial tests on the dependent variables indicate the variables are not normally distributed. To address this concern, the natural logarithm of each variable is used as the dependent variable.

Although the focus of this chapter is on the effect of short-sale constraints, it is well known that a short position can be replicated using derivatives such as exchange traded options.[22] Even though it is debatable whether derivatives reduce short-sale constraints in an economically meaningful way,[23] it is important to note that stocks in this sample may have options listed. However, the effect of listed options on sample stocks is likely to minimise the impact of the short-sales bans, thereby reducing the magnitude of the results.

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[22] Figlewski and Webb (1993) find that constrained investors will buy puts and write calls as a substitute for short-selling.

[23] Mayhew and Mihov (2005) is part of an emerging wave of studies which document options do not reduce short-sale constraints. Other studies include: Mayhew and Mihov (2004), Ofek, Richardson and Whitelaw (2004), Lakonishok, Lee and Poteshman (2004), Brunnermeier and Nagel (2004), Lamont and Stein (2004), Battalio and Schultz (2006), Danielsen, Van Ness and Warr (2007) and Bris, Goetzmann and Zhu (2007).

Table 3-2 Control sample selection

For each market this table lists the main market index used to select control stocks. The description of each index is provided and whether any adjustments are made to the index to select the control sample. If not stated in the description, all stocks in the treatment sample (stocks subject to the short-selling bans) are removed from the control sample.

Market	Index	Index description and control sample definition
United States	NYSE Composite	All common stocks listed on NYSE. Use the largest 300 stocks based on market-capitalisation
United Kingdom	FTSE 100	Largest 100 stocks on the London Stock Exchange based on market capitalisation
Canada	S&P/TSX 60	Largest 60 stocks on the Toronto Stock Exchange based on market capitalisation
Switzerland (SWX Europe)	Swiss market	Largest 30 stocks on SWX Europe based on market capitalisation
Norway	OBX Index	25 most liquid stocks on the Oslo Stock Exchange based on six-month turnover
Netherlands	AEX index	25 most actively traded (Euro Turnover) stocks in the Euronext Amsterdam
Germany	DAX	30 largest stocks on the Frankfurt Stock Exchange based on market capitalisation and volume
Portugal	PSI-20	20 largest stocks on the Euronext Lisbon based on market capitalisation and volume
Italy	FTSE MIB	40 largest stocks on the Borsa Italiana based on market capitalisation and volume
France	CAC 40	40 stocks among the 100 largest stocks on Euronext Paris based on market capitalisation and volume
Belgium	BEL20	20 largest stocks on Euronext Brussels based on market capitalisation and volume
Sweden	OMX Stockholm 30	30 most liquid stocks on Stockholm Stock Exchange based on six-month turnover
Japan	S&P/TOPIX 150	150 of the largest stocks on the Tokyo Stock Exchange based on market capitalisation and Turnover value
Hong Kong	Hang Seng Index	42 stocks on the Hong Kong Stock Exchange based on market capitalisation and turnover

3.5 Results

3.5.1 Abnormal returns

Table 3-3 reports ARs and CARs, calculated using the market model and market-adjusted model, around the event date (denoted day 1) for various windows before and after all events. Figures 3-1 to 3-6 represent the results graphically and separated by the level of short-selling constraint imposed (based on the market model).[24] Figure 3-1 presents daily ARs for the markets subject to a *covered* short-selling ban. During the pre-event period (10 trading days), abnormal returns are mixed with several strong negative abnormal returns leading into the restrictions. Surprisingly, on the day preceding the bans (-1) there are positive abnormal returns in Canada and the US, which are significant at the 5% level. This could be attributable to the market-wide naked short-selling ban which was announced and implemented on this day in the US.[25]

On the event day, prices impound the implementation of the short-selling bans, with the US, Canada, UK and Switzerland all experiencing positive abnormal returns of at least 2%. On the following days, the majority of abnormal returns are positive for all markets. This is highlighted in Figure 3-2, which plots the CARs. Table 3-3 documents that four of the five markets subject to the covered ban experience positive abnormal returns over the post-event (10 trading days) period. Over this period,

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[24] The results from the market-adjusted model are qualitatively similar to the market model; thus only the results of the market model are discussed and presented in Figures 3-1 to 3-6.

[25] The SEC naked short-selling ban was implemented 17 September, 2008, and restricted naked short-selling of all US stocks, effective 18 September, 2008.

abnormal returns are 5.43%, 9.37%, -2.28%, 12.71% and 11.33% respectively in the UK, US, Norway, Canada and Switzerland. These returns are significantly different from zero, at the 5% level using a *t*-test, and 10% level using a sign-rank test, in all markets except Norway. The positive abnormal returns when covered short-selling is restricted are consistent with the disagreement models and the first hypothesis ($H_{3,1}$).

Figure 3-3 presents the daily ARs for the markets subject to a *naked* short-selling ban. Miller (1977) suggests that the magnitude of abnormal returns could be affected by the level of short-selling constraint. If restricting naked short-selling is not an economically meaningful constraint then abnormal returns would not be expected. Similar to stocks subject to the covered short-selling ban, Figure 3-3 shows that the pre-event period is dominated by negative abnormal returns. However, on the two trading days preceding the bans there are positive abnormal returns in the majority of markets. These returns can be attributable to the timing of the naked short-selling bans. The naked bans were enforced on 22 and 23 September, 2008, while the covered bans in the UK and US were enforced on 19 September, 2008. The positive abnormal returns can be attributed to the expectation of a similar ban being enforced or the strong correlation between the returns of global financial markets. Similar to the covered ban sample, all six markets experience positive abnormal returns in the post-event period (four are significant at the 10% level). While not as significant as for covered short-selling bans, naked short-selling bans exhibit similar stock price reactions to covered short-selling bans.

Table 3-3 Abnormal returns around 2008 short-selling bans

This table reports abnormal returns and cumulative abnormal returns based on the market model (Panel A) and market-adjusted model (Panel B) around short-selling bans. The event date, the day the short-selling ban is imposed, is denoted day 1. The estimation window for the market model begins 1 July, 2007 and ends 31 August, 2008. Results are separated by the type of short-selling ban imposed. *Covered ban* indicates the market had a ban on covered short-selling. *Naked ban* indicates the market had a ban on naked short-selling. *No ban* indicates the market had no ban on short-selling imposed over the same period as the US ban. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively, using a parametric *t*-test. $^{+}$, $^{++}$, and $^{+++}$ denote significance at the 10%, 5%, and 1% levels, respectively, using a Wilcoxon sign-rank test.

Panel A: Market Model					
	CAR	AR	AR	CAR	CAR
Market	(-10,-1)	(-1)	(1)	(-1,10)	(1,10)
Covered Ban					
UK	-0.0304	-0.0190^{++}	0.0267***$^{+++}$	0.0353^{+}	0.0543**$^{+++}$
US	0.0607***$^{+++}$	0.0357***$^{+++}$	0.0278***$^{+++}$	0.1313***$^{+++}$	0.0937***$^{+++}$
Norway	-0.0348	-0.0382	0.0034	-0.0610	-0.0228
Canada	-0.0170	0.0436**$^{++}$	0.0214***$^{++}$	0.1707***$^{+++}$	0.1271***$^{+++}$
Switzerland	-0.0775*	0.0018	0.0507	0.1151*$^{+}$	0.1133**$^{+}$
Naked Ban					
Netherlands	-0.0439	0.0512	-0.0099	0.0866	0.0354
Belgium	-0.0153	0.0845***	-0.0521	0.1497***$^{+}$	0.0653*$^{+}$
Germany	-0.0028	0.0459***$^{+++}$	-0.0021	0.1230**$^{++}$	0.0771*$^{+}$
Portugal	0.0747**$^{++}$	0.0289	-0.0034	0.1134**$^{++}$	0.0845**$^{++}$
Italy	0.0241*	0.0125***$^{+++}$	-0.0027	0.0234	0.0109
France	0.0164	0.0482***$^{+++}$	0.0038	0.1329***$^{+++}$	0.0847***$^{+++}$
No Ban					
Hong Kong	-0.0018	-0.0035	0.0387***$^{++}$	0.0255	0.0254
Sweden	0.0124	0.0130	0.0616***	0.1332***	0.1201***
Japan	0.0168	-0.0207***$^{+++}$	0.0302***$^{+++}$	0.0969***$^{+++}$	0.1177***$^{+++}$

Table 3-3 – Continued

Panel B: Market-adjusted					
	CAR	AR	AR	CAR	CAR
Market	(-10,-1)	(-1)	(1)	(-1,10)	(1,10)
Covered ban					
UK	-0.0516*	-0.0200*$^{++}$	0.0334**$^{+++}$	0.0193+	0.0393+++
US	0.0329***$^{+++}$	0.0331***$^{+++}$	0.0264***$^{+++}$	0.1011***$^{+++}$	0.0656***$^{+++}$
Norway	0.0506	-0.0299	-0.0054	-0.1149	-0.0850
Canada	-0.0281	0.0413**$^{++}$	0.0081	0.1648***$^{+++}$	0.1235***$^{+++}$
Switzerland	-0.0964**$^{+}$	0.0005	0.0603***$^{++}$	0.0963*$^{+}$	0.0957**$^{+}$
Naked Ban					
Netherlands	-0.0532	0.0425	-0.0083	0.0880	0.0455
Belgium	-0.0208	0.1013***	-0.0549*	0.1309***	0.0296
Germany	-0.0192	0.0423***$^{++}$	-0.0012	0.1236***$^{+++}$	0.0813***$^{+++}$
Portugal	0.0718**$^{++}$	0.0141	-0.0055	0.1048**$^{++}$	0.0906**$^{++}$
Italy	0.0216*	0.0137***$^{+++}$	-0.0006	0.0366***$^{+++}$	0.0228^{+}
France	0.0110	0.0457***$^{+++}$	0.0040	0.1288***$^{+++}$	0.0831***$^{+++}$
No Ban					
Hong Kong	0.0169	-0.0015	0.0328**$^{+}$	0.0341	0.0328
Sweden	0.0104	0.0124	0.0570***	0.1269***	0.1145***
Japan	-0.0210	-0.0273***$^{+++}$	0.0442***$^{+++}$	0.0606**$^{++}$	0.0879***$^{+++}$

Figure 3-1 Abnormal returns: Covered bans

This figure reports abnormal returns based on the market model around covered short-selling bans. The event date, the day the short-selling ban is imposed, is denoted day 1. The estimation window for the market model begins 1 July, 2007 and ends 31 August, 2008.

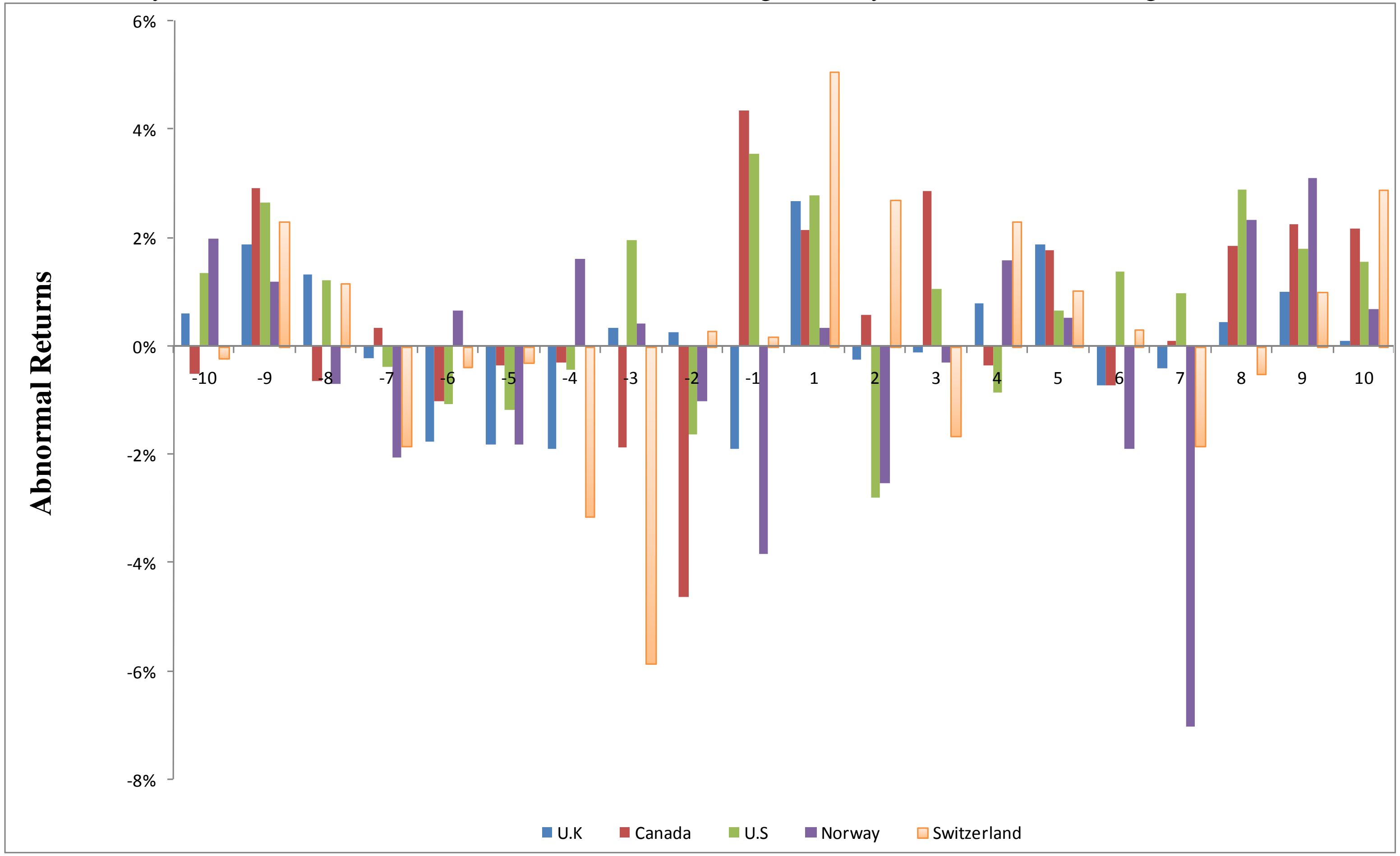


Figure 3-2 Cumulative abnormal returns: Covered bans

This figure reports cumulative abnormal returns based on the market model around covered short-selling bans. The event date, the day the short-selling ban is imposed, is denoted day 1. The estimation window for the market model begins 1 July, 2007 and ends 31 August, 2008.

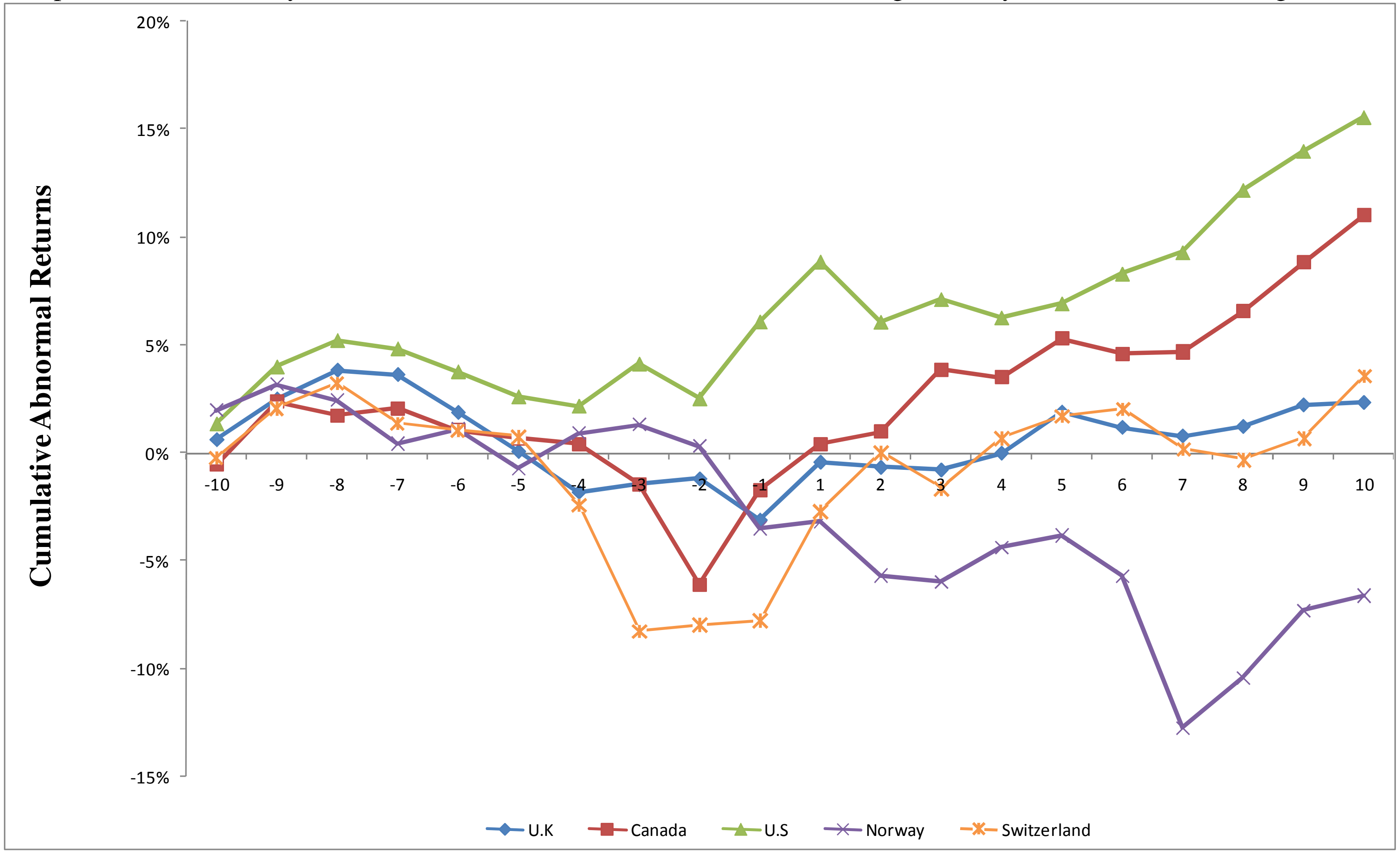


Figure 3-3 Abnormal returns: Naked bans

This figure reports abnormal returns based on the market model around naked short-selling bans. The event date, the day the short-selling ban is imposed, is denoted day 1. The estimation window for the market model begins 1 July, 2007 and ends 31 August, 2008.

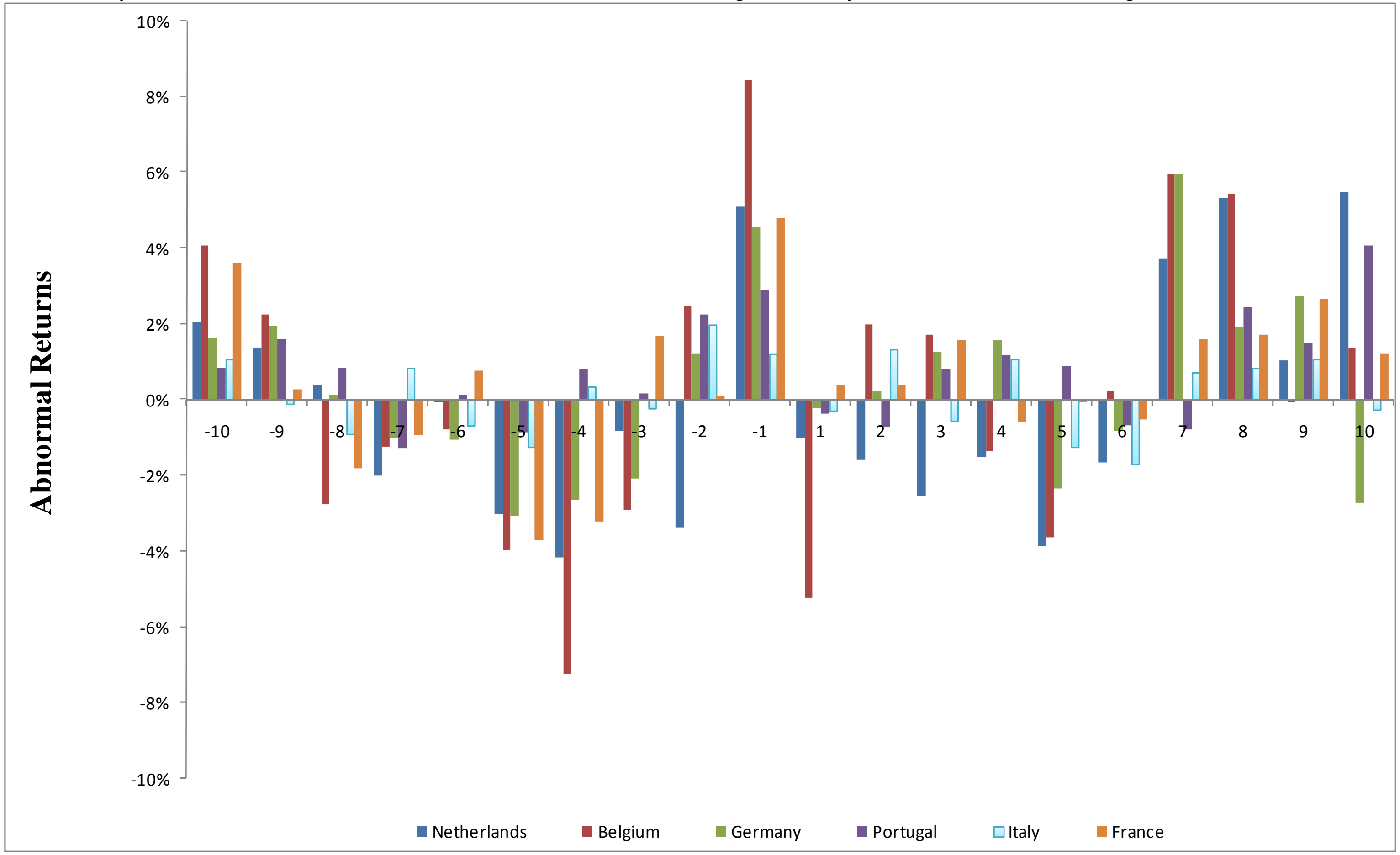
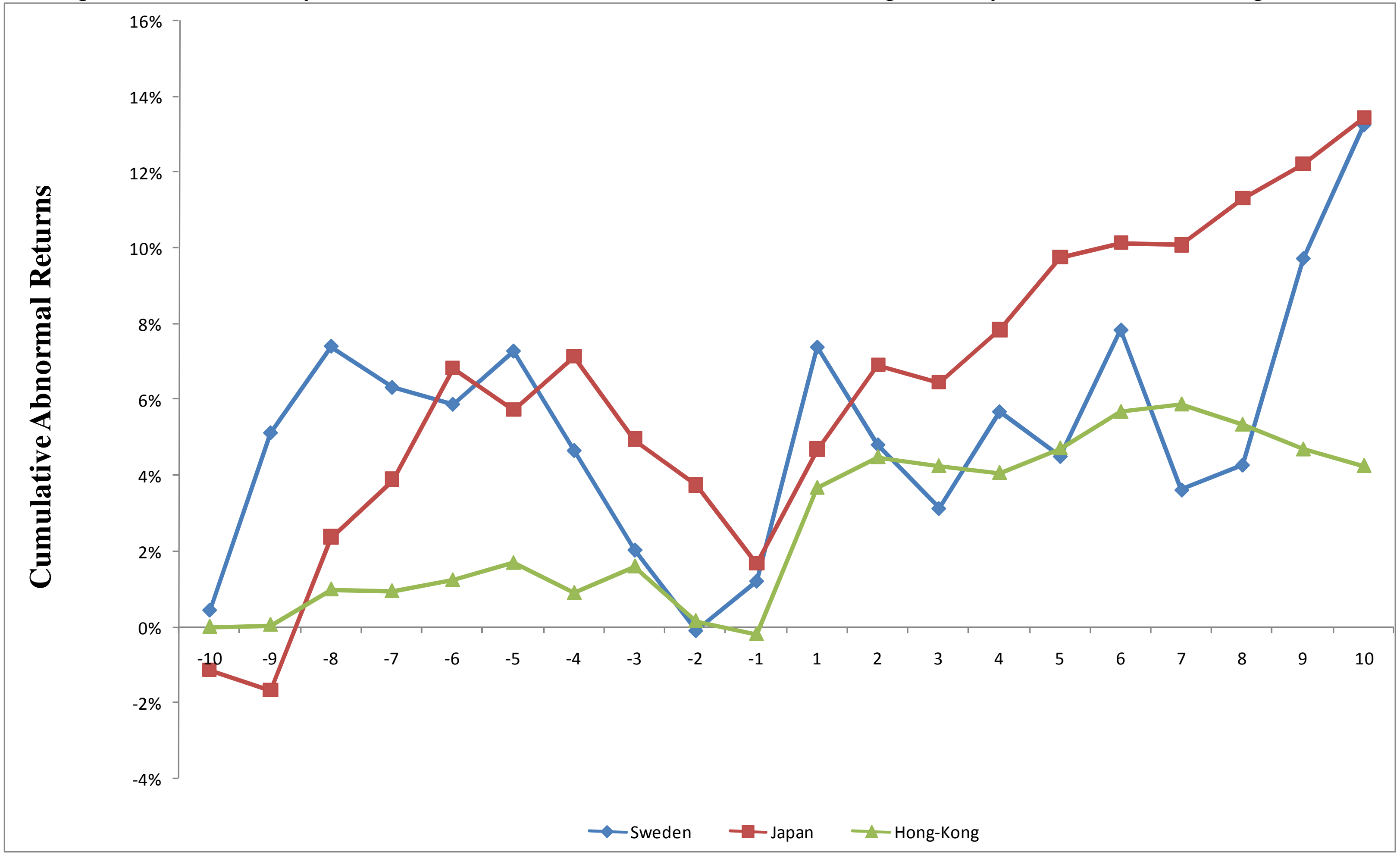


Figure 3-4 Cumulative abnormal returns: Naked bans

This figure reports cumulative abnormal returns based on the market model around naked short-selling bans. The event date, the day the short-selling ban is imposed, is denoted day 1. The estimation window for the market model begins 1 July, 2007 and ends 31 August, 2008.



The results in Table 3-3 provide support for the first hypothesis ($H_{3,1}$) with positive abnormal returns when short-selling is restricted. To provide further evidence, markets where no short-selling bans were announced over the same period as the US ban are examined. Figure 3-5 presents ARs for markets without short-selling bans. In the pre-event period, stocks experience a mixture of returns similar to the covered sample. On the event date, stocks experience positive abnormal returns which persist over the post-event window. Figure 3-6 highlights the magnitude of these results and Table 3-3 documents that Sweden, Japan and Hong Kong experience abnormal returns of 12.01%, 11.77% and 2.54% in the post-event period, respectively.

The similar returns on markets with no bans and covered bans indicate that *either* the results are not directly attributable to the short-selling restrictions *or* the short-selling restrictions in major markets (i.e., US) affect global markets. Evidence in Table 3-3 suggests the latter is more likely. All three markets not subject to a ban experience positive abnormal returns on the same day as the US bans. If the result was attributable to other factors (e.g., various government stimulus packages), it is unlikely that all three markets would react on the same day as the US bans. Further evidence exists in markets where naked short-selling is prohibited. In these markets, strong positive abnormal returns occur on the two trading days preceding the bans, coinciding with the UK and US bans. The notion of interdependence between global stock price movements is extensively documented (see Forbes and Rigobon, 2002), and appears to be the most likely explanation of the results.

Overall, the results in Table 3-3 support the first hypothesis ($H_{3,1}$) with positive abnormal returns when short-selling is restricted. This is expected, given the theory

(Miller, 1977) and previous studies that document positive abnormal returns when short-sales are constrained. It appears that the regulations were successful, given the unofficial purpose of the bans was to sustain the prices of struggling financial stocks. The bans have successfully, albeit possibly temporarily, inflated the prices of financial companies.

3.5.2 Market quality: Descriptive statistics

Table 3-4 provides descriptive statistics for the control and treatment sample in the pre- and post-event windows for each of the markets subject to a covered short-selling ban. Difference captures the percentage change in each sample when the short-selling restrictions are enforced. Diff-diff captures the difference in the percentage change between the stocks affected by the ban and the stocks not affected. The descriptive statistics indicate that trading volume and value are reduced, controlling for market-wide changes in trading activity, when covered short-selling is restricted. Across all five markets, with the exception of turnover value in Canada, the Diff-diff results are homogenous, with both volume and value reduced by a minimum of 11.6%. Relative bid-ask spreads widen by a minimum of 18.1% during the bans, after controlling for market-wide changes. At the same time both stock price and return volatility increase in the US, UK and Norway, while falling in Switzerland. Overall the descriptive statistics suggest that market quality deteriorates when covered short-selling is restricted.

Figure 3-5 Abnormal returns: No bans

This figure reports cumulative abnormal returns based on the market model around markets with no short-selling bans. The event date, the day the short-selling ban is imposed, is denoted day 1. The estimation window for the market model begins 1 July, 2007 and ends 31 August, 2008.

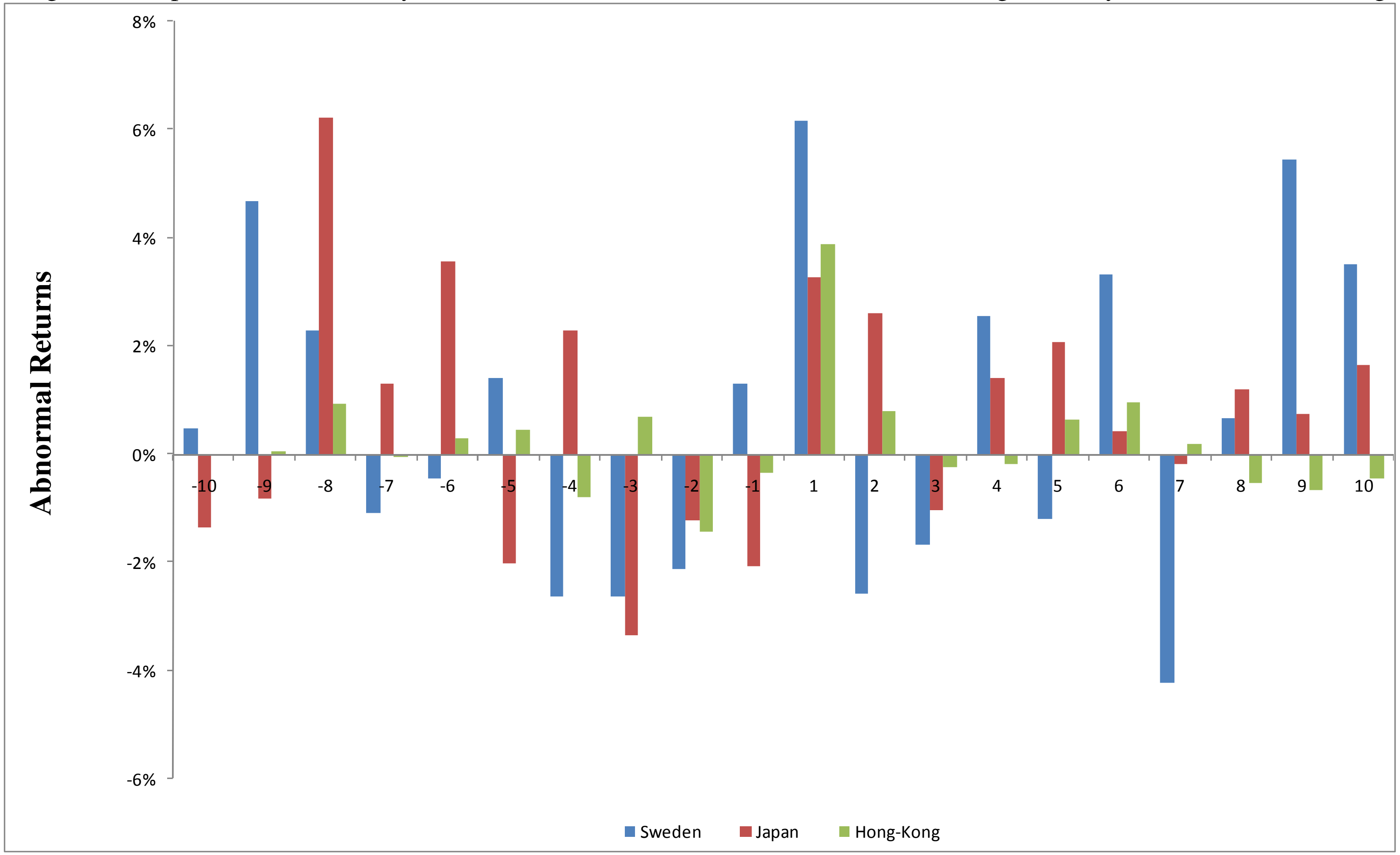


Figure 3-6 Cumulative abnormal returns: No bans

This figure reports abnormal returns based on the market model around markets with no short-selling bans. The event date, the day the short-selling ban is imposed, is denoted day 1. The estimation window for the market model begins 1 July, 2007 and ends 31 August, 2008.

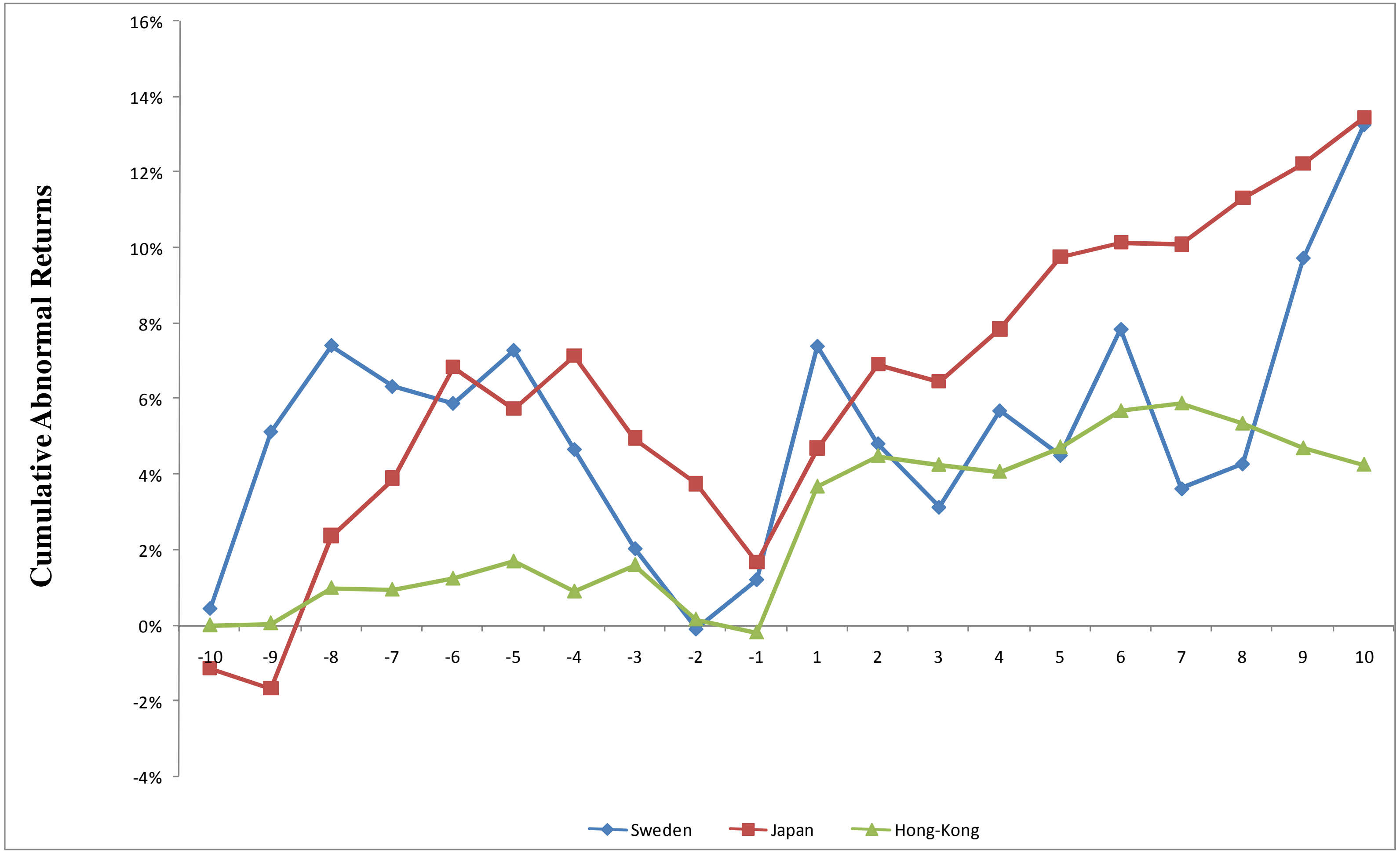


Table 3-4 Descriptive statistics: Covered bans

This table reports descriptive statistics for markets with a ban on covered short-selling. The treatment sample includes stocks subject to the short-selling ban. The control sample includes stocks from a major index in the corresponding market not affected by the short-selling restrictions (see Table 3-2). Variables include: Spread (Relative bid-ask spread), Price volat. (Daily price volatility), Return volat. (Daily return volatility), Value (Daily turnover value) and Volume (Daily traded volume). The event date, the day the short-selling ban is imposed, is denoted day 1. The Pre and Post columns represent the cross-sectional average of each variable for the pre- (30 trading days prior to event) and post-event (30 trading days subsequent to event) period. If the ban was in place for less than 30 trading days, the duration of the ban is used as the post-event window. The Change (%) column reports the percentage difference between the Pre and Post averages for each variable in both the treatment and control samples. The Diff-diff column reports the difference of the difference between the treatment and control samples.

		Treatment			Control			
	Measure	Pre	Post	Change (%)	Pre	Post	Change (%)	Diff-Diff
Canada	Spread	0.0110	0.0199	81.07	0.0037	0.0051	40.94	40.94
	Price volat.	0.0464	0.0776	67.10	0.0470	0.0708	50.75	16.36
	Return volat	0.0019	0.0041	117.43	0.0013	0.0028	110.21	7.22
	Value	94,616,460	115,534,207	22.11	89,120,115	106,352,900	19.34	2.77
	Volume	2,138,664	2,495,069	16.66	2,150,575	2,809,973	30.66	-14.00
Norway	Spread	0.0070	0.0155	122.74	0.0036	0.0045	25.23	97.51
	Price volat.	0.0686	0.1004	103.57	0.0911	0.1175	28.97	17.31
	Return volat	0.0037	0.0076	46.28	0.0048	0.0087	80.27	23.29
	Value	202,238,369	131,412,381	-35.02	395,076,587	302,640,008	-23.40	-11.62
	Volume	10,553,764	8,791,287	-16.70	6,271,125	7,070,656	12.75	-29.45

Table 3-4 – Continued

Switzerland	Spread	0.0017	0.0032	83.47	0.0017	0.0028	65.31	18.16
	Price volat.	0.0438	0.0811	85.25	0.0291	0.0552	89.69	-4.44
	Return volat	0.0013	0.0058	340.26	0.0004	0.0020	355.13	-14.87
	Value	323,866,683	353,580,886	9.17	206,561,724	308,806,204	49.50	-40.32
	Volume	8,296,163	9,530,835	14.88	3,693,960	5,990,106	62.16	-47.28
UK	Spread	0.0023	0.0053	128.91	0.0017	0.0019	10.82	118.09
	Price volat.	0.0451	0.1152	155.16	0.0415	0.0724	74.48	80.68
	Return volat	0.0022	0.0084	283.46	0.0011	0.0034	207.70	75.77
	Value	180,374,676	149,439,043	-17.15	48,689,542	50,933,474	4.61	-21.76
	Volume	13,542,515	16,171,673	19.41	3,192,122	4,257,075	33.36	-13.95
US	Spread	0.0043	0.0150	249.47	0.0017	0.0032	92.54	156.93.
	Price volat.	0.0568	0.0928	63.44	0.0356	0.0561	57.51	5.93
	Return volat	0.0025	0.0062	150.31	0.0011	0.0026	149.08	1.23
	Value	35,868,769	34,865,404	-2.80	66,214,144	77,925,182	17.69	-20.48
	Volume	1,247,519	1,147,591	-8.01	1,451,731	1,850,830	27.49	-35.50

Table 3-5 provides descriptive statistics for the control and treatment samples in the pre- and post-event windows for each of the markets subject to a naked short-selling ban. The descriptive statistics suggest that trading volume and turnover value are reduced, controlling for market-wide changes in trading activity, when naked short-selling is restricted. Across five of the six markets, the Diff-diff results show both volume and value are reduced, consistent with the covered short-selling ban results. However, the effect on bid-ask spreads and stock price and return volatility is mixed across markets. For example, Portugal and Italy experience a reduction in spreads, while the Netherlands, Belgium, France and Germany experience an increase. Overall, the descriptive statistics provide inconclusive evidence of the impact of the naked short-selling ban on market quality.

Table 3-6 provides descriptive statistics for the control (non-financial stocks) and treatment (financial stocks) samples in the pre- and post-event windows for the three markets not subject to a short-selling ban. Similar to the naked ban sample, the descriptive statistics provide mixed results, with no consistent result across markets. The only measure which changes in the same direction across the three markets is turnover value (which increases).

3.5.3 Market quality: Pooled cross-sectional regressions

The descriptive statistics provide an indication of the impact of the short-selling bans on market quality. To provide formal statistical testing and to control for other factors, the results of the cross-sectional pooled regressions are presented in Tables 3-7, 3-8 and 3-9. The key variable, Ban_i, captures the marginal impact of the short-selling ban on the market quality variable of interest.

Table 3-7 presents the results for the markets where a covered ban was imposed. The results are similar to the descriptive statistics across the five markets. Consistent with the second hypothesis ($H_{3,2}$), stock price and return volatility measures increase significantly in four of the five markets with the coefficient, Ban_i, positive and statistically significant at the 1% level. Consistent with the third hypothesis ($H_{3,3}$), relative bid-ask spreads increase in four of the five markets with the coefficient, Ban_i, positive and statistically significant at the 1% level. Consistent with the fourth hypothesis ($H_{3,4}$), volume and value decrease significantly in four of the five markets with the coefficient, Ban_i, negative and statistically significant at the 5% level. Consistent with the univariate results, banning covered short-sales has a negative impact on market quality.

Table 3-8 presents the results from the six markets where a naked ban was imposed. The results are similar to the descriptive statistics, with inconsistent results across the six markets. Unlike markets where a covered ban was in place, no clear pattern exists across the markets subject to a naked ban. This suggests that the naked ban does not significantly impact on market quality.

Table 3-5 Descriptive statistics: Naked bans

This table reports descriptive statistics for markets with a ban on naked short-selling. The treatment sample includes stocks subject to the short-selling ban. The control sample includes stocks from a major index in the corresponding market not affected by the short-selling restrictions (see Table 3-2). Variables include: Spread (Relative bid-ask spread), Price volat. (Daily price volatility), Return volat. (Daily return volatility), Value (Daily turnover value) and Volume (Daily traded volume). The event date, the day the short-selling ban is imposed, is denoted day 1. The Pre and Post columns represent the cross-sectional average of each variable for the pre- (30 trading days prior to event) and post-event (30 trading days subsequent to event) period. If the ban was in place for less than 30 trading days, the duration of the ban is used as the post-event window. The Change (%) column reports the percentage difference between the Pre and Post averages for each variable in both the treatment and control samples. The Diff-diff column reports the difference of the difference between the treatment and control samples.

		Treatment			Control			
	Measure	Pre	Post	Change (%)	Pre	Post	Change (%)	Diff-Diff
Netherlands	Spread	0.0023	0.0053	128.91	0.0017	0.0019	10.82	118.09
	Price volat.	0.0451	0.1152	155.16	0.0415	0.0724	74.48	80.68
	Return volat	0.0022	0.0084	283.46	0.0011	0.0034	207.70	75.77
	Value	180,374,676	149,439,043	-17.15	48,689,542	50,933,474	4.61	-21.76
	Volume	13,542,515	16,171,673	19.41	3,192,122	4,257,075	33.36	-13.95
Belgium	Spread	0.0022	0.0047	112.33	0.0051	0.0063	22.01	90.32
	Price volat.	0.0553	0.1206	118.10	0.0328	0.0588	79.18	38.92
	Return volat	0.0038	0.0091	137.66	0.0007	0.0015	117.79	19.87
	Value	58,258,378	49,153,465	-15.63	12,433,809	14,616,580	17.56	-33.18
	Volume	4,474,789	5,475,175	22.36	253,584	362,267	42.86	-20.50

Table 3-5 – Continued

Germany	Spread	0.0038	0.0070	84.55	0.0032	0.0042	32.16	52.39
	Price volat.	0.0374	0.0879	135.14	0.0305	0.0639	109.44	25.71
	Return volat	0.0012	0.0045	280.48	0.0008	0.0022	180.63	99.85
	Value	12,618,064	27,678,527	119.36	12,589,129	19,660,480	56.17	63.19
	Volume	426,177	1,528,809	258.73	218,740	387,072	76.96	181.77
Portugal	Spread	0.0200	0.0204	1.85	0.0042	0.0065	55.67	-53.82
	Price volat.	0.0329	0.0554	68.27	0.0371	0.0661	78.08	-9.81
	Return volat	0.0009	0.0015	71.08	0.0010	0.0026	152.32	-81.24
	Value	2,724,731	2,845,976	4.45	9,664,562	10,522,949	8.88	-4.43
	Volume	611,871	703,314	14.94	1,977,560	2,431,432	22.95	-8.01
Italy	Spread	0.0064	0.0090	40.49	0.0017	0.0028	59.16	-18.67
	Price volat.	0.0349	0.0562	61.01	0.0366	0.0632	72.65	-11.64
	Return volat	0.0009	0.0024	178.35	0.0008	0.0024	209.87	-31.52
	Value	58,645,381	50,389,008	-14.08	83,991,619	74,807,017	-10.94	-3.14
	Volume	16,061,754	17,207,044	7.13	12,939,133	14,471,229	11.84	-4.71
France	Spread	0.0048	0.0099	107.89	0.0008	0.0008	2.87	105.02
	Price volat.	0.0474	0.0742	56.49	0.0376	0.0671	78.63	-22.13
	Return volat	0.0025	0.0030	18.72	0.0010	0.0033	239.45	-220.73
	Value	122,691,686	105,670,112	-13.87	122,509,660	148,606,834	21.30	-35.18
	Volume	5,634,349	4,914,412	-12.78	4,201,602	5,628,709	33.97	-46.74

Table 3-6 Descriptive statistics: No bans

This table reports descriptive statistics for markets with no ban on short-selling. The treatment sample includes financial stocks. The control sample includes stocks from a major index in the corresponding market, excluding stocks in the treatment sample (see Table 3-2). Variables include: Spread (Relative bid-ask spread), Price volat. (Daily price volatility), Return volat. (Daily return volatility), Value (Daily turnover value) and Volume (Daily traded volume). The event date, the day the short-selling ban is imposed, is denoted day 1. The Pre and Post columns represent the cross-sectional average of each variable for the pre- (30 trading days prior to event) and post-event (30 trading days subsequent to event) period. If the ban was in place for less than 30 trading days, the duration of the ban is used as the post-event window. The Change (%) column reports the percentage difference between the Pre and Post averages for each variable in both the treatment and control samples. The Diff-diff column reports the difference of the difference between the treatment and control samples.

		Treatment			Control			
	Measure	Pre	Post	Change (%)	Pre	Post	Change (%)	Diff-Diff
Hong Kong	Spread	0.0038	0.0068	76.85	0.0025	0.0036	41.65	35.20
	Price volat.	0.0412	0.0536	30.17	0.0461	0.0637	38.20	-8.03
	Return volat	0.0011	0.0019	73.34	0.0014	0.0025	74.60	-1.27
	Value	1,260,957,391	1,418,314,229	12.48	503,558,295	529,395,175	5.13	7.35
	Volume	120,725,912	124,808,746	3.38	28,952,215	33,680,747	16.33	-12.95
Japan	Spread	0.0030	0.0036	19.02	0.0030	0.0036	18.10	0.92
	Price volat.	0.0397	0.0530	33.58	0.0292	0.0438	50.02	-16.44
	Return volat	0.0019	0.0020	6.73	0.0008	0.0015	90.63	-83.90
	Value	16,726,433,719	21,566,516,226	28.94	7,748,624,072	8,720,299,346	12.54	16.40
	Volume	8,087,073	11,522,280	42.48	5,788,440	7,236,714	25.02	17.46
Sweden	Spread	0.0022	0.0025	12.02	0.0028	0.0032	14.87	-2.85
	Price volat.	0.0411	0.0691	68.26	0.0380	0.0532	39.96	28.29
	Return volat	0.0012	0.0048	305.92	0.0009	0.0020	129.42	176.50
	Value	817,957,682	1,083,384,174	32.45	445,342,584	533,260,198	19.74	12.71
	Volume	7,652,489	10,635,257	38.98	5,106,250	6,253,921	22.48	16.50

Table 3-7 Pooled cross-sectional regressions: Covered bans

This table reports pooled cross-sectional regression results from markets with a ban on covered short-selling for the following regression: $Y_{it} = \beta_{0t} + \beta_{1t}\, Period_i + \beta_{2t}\, Sample_i + \beta_{3t}\, Ban_i + \varepsilon_{it}$

The pooled data include: both the treatment and control samples over the pre- (30 trading days prior to event) and post-event (30 trading days subsequent to event) period. If the ban was in place for less than 30 trading days, the duration of the ban is used as the post-event window. The treatment sample includes stocks subject to the short-selling ban. The control sample includes stocks from a major index in the corresponding market not affected by the short-selling restrictions (see Table 3-2). Y_{it} is the market quality measure of interest for stock *i* during interval *t*. Market quality measures include: Spread (Relative bid-ask spread), Price volat. (Daily price volatility), Return volat. (Daily return volatility), Value (Daily turnover value) and Volume (Daily traded volume). Ban_i is a dummy variable equal to one if the stocks are subject to a short-selling ban, and zero otherwise. $Period_i$ is a control dummy variable equal to one if the observation lies in the post-event period, and zero otherwise. $Sample_i$ is a control dummy variable equal to one if the observation belongs to the treatment sample, and zero otherwise. The regressions include calendar-day dummy variables and stock dummy variables, and the standard errors take into account clustering by calendar date and clustering by stock (Thompson, 2009). *, **, and *** denote significance at the 10%, 5%, and 1% levels.

Market	Measure	Intercept	Period	Sample	Ban	R^2
UK	Spread	-7.126***	0.243***	4.106***	0.301***	0.60
	Price volat.	0.121***	0.052***	-0.094***	0.018***	0.62
	Return volat.	-6.387***	0.820***	-0.695	0.172***	0.60
	Value	24.121***	0.453***	-10.784***	-0.303***	0.95
	Volume	16.544***	0.599***	-7.537***	-0.329***	0.95
US	Spread	-6.611***	0.628***	1.113***	0.783***	0.59
	Price volat.	0.037***	0.033***	0.012**	0.017***	0.66
	Return volat.	-8.102***	1.821***	-0.465	0.127***	0.65
	Value	17.632***	0.476***	-2.055***	-0.440***	0.96
	Volume	13.479***	0.619***	-1.447***	-0.510***	0.95
Norway	Spread	-5.669***	0.716***	0.455***	0.332***	0.40
	Price volat.	0.118***	-0.016	0.010	0.009	0.53
	Return volat.	-5.704***	0.273	-0.099	-0.026	0.60
	Value	20.591***	-0.530***	-2.623***	-0.246***	0.91
	Volume	15.704***	-0.134	-0.679***	-0.284***	0.88
Canada	Spread	-5.513***	-0.117	-1.179***	0.438***	0.43
	Price volat.	0.096***	0.039***	-0.043***	0.007***	0.64
	Return volat.	-5.687***	2.742***	-1.279**	0.266***	0.63
	Value	18.384***	0.643***	-0.070	0.094*	0.94
	Volume	16.179***	0.801***	-1.426***	0.018	0.91
Switzerland	Spread	-5.550***	0.703***	-0.590***	0.001	0.38
	Price volat.	0.068***	0.035***	-0.016***	0.011***	0.64
	Return volat.	-8.182***	1.026*	-0.087	0.216***	0.59
	Value	18.230***	0.214*	1.501***	-0.437***	0.88
	Volume	13.123***	0.603***	1.368***	-0.366***	0.96

Table 3-8 Pooled cross-sectional regressions: Naked bans

This table reports pooled cross-sectional regression results from markets with a ban on naked short-selling for the following regression:

$$Y_{it} = \beta_{0t} + \beta_{1t} Period_i + \beta_{2t} Sample_i + \beta_{3t} Ban_i + \varepsilon_{it}$$

The pooled data includes: both the treatment and control samples over the pre- (30 trading days prior to event) and post-event (30 trading days subsequent to event) period. If the ban was in place for less than 30 trading days the duration of the ban is used as the post-event window. The treatment sample includes stocks subject to the short-selling ban. The control sample includes stocks from a major index in the corresponding market not affected by the short-selling restrictions (see Table 3-2). Y_{it} is the market quality measure of interest for stock *i* during interval *t*. Market quality measures include: Spread (Relative bid-ask spread), Price volat. (Daily price volatility), Return volat. (Daily return volatility), Value (Daily turnover value) and Volume (Daily traded volume). Ban_i is a dummy variable equal to one if the stocks are subject to a short-selling ban, and zero otherwise. $Period_i$ is a control dummy variable equal to one if the observation lies in the post-event period, and zero otherwise. $Sample_i$ is a control dummy variable equal to one if the observation belongs to the treatment sample, and zero otherwise. The regressions include calendar-day dummy variables and stock dummy variables, and the standard errors take into account clustering by calendar date and clustering by stock (Thompson, 2009). *, **, and *** denote significance at the 10%, 5%, and 1% levels.

Market	Measure	Intercept	Period	Sample	Ban	R^2
Netherlands	Spread	-6.397***	-0.249	0.445**	0.561***	0.42
	Price volat.	0.100***	0.089***	0.014**	0.045***	0.69
	Return volat.	-7.277***	0.697	0.451	0.798***	0.68
	Value	16.710***	0.530***	-0.421***	-0.095	0.95
	Volume	11.824***	0.739***	2.240***	0.128**	0.97
Belgium	Spread	-6.157***	0.740**	0.592**	0.493**	0.44
	Price volat.	0.110***	0.070***	-0.005	0.045***	0.64
	Return volat.	-6.649***	1.777***	0.701*	0.077***	0.65
	Value	17.360***	0.598***	-0.925***	-0.340***	0.91
	Volume	14.251***	0.692***	-1.687***	-0.042	0.95
Germany	Spread	-6.784***	0.078	0.372***	0.200***	0.76
	Price volat.	0.093***	0.055***	-0.032***	0.018***	0.64
	Return volat.	-7.731***	2.147***	-1.246***	0.379***	0.65
	Value	17.576***	0.606**	-2.151***	0.215*	0.73
	Volume	12.135***	0.780***	-1.338***	0.347***	0.73
Portugal	Spread	-5.226***	0.320	1.934***	-0.005	0.47
	Price volat.	0.081***	0.050***	-0.001	-0.006**	0.59
	Return volat.	-8.841***	1.484***	0.295	0.025	0.68
	Value	15.645***	0.383**	-3.523***	0.033	0.91
	Volume	14.040***	0.484**	-4.235***	-0.063	0.91

Table 3-8 – Continued

Italy	Spread	-6.558***	0.604***	2.035***	-0.088	0.63
	Price volat.	0.067***	0.046***	-0.002	-0.005***	0.60
	Return volat.	-8.314***	1.504***	-1.088**	-0.069*	0.68
	Value	17.786***	0.512***	-6.341***	0.026	0.97
	Volume	15.125***	0.640***	-5.958***	-0.013	0.97
France	Spread	-7.639***	0.175	-0.383*	0.577***	0.60
	Price volat.	0.086***	0.042***	0.009*	-0.002	0.62
	Return volat.	-7.021***	0.035	-0.054	-0.870	0.61
	Value	18.842***	0.595***	1.359***	-0.285***	0.97
	Volume	13.896***	0.756***	2.266***	-0.337***	0.97

Table 3-9 presents the results from the three markets without short-selling bans. Results documented are similar to the descriptive statistics, with largely insignificant and inconsistent results. Trading volume, turnover value and relative bid-ask spreads do not change significantly, with the coefficient, Ban_i, statistically insignificant. Price and return volatility results are mixed across markets and suggest no clear impact from the US short-selling bans. These results suggest the US bans had no significant impact on market quality measures in markets without short-selling bans.

Overall, results indicate that market quality is markedly worse for markets with more stringent short-selling restrictions. Markets with covered short-selling bans on financial stocks experience a significant decline in market quality (for stocks subject to the ban). This is possibly driven by the temporary exclusion of certain market participants, including hedge funds and proprietary trading desks, which typically provide substantial amounts of liquidity via short-selling. This result does not extend to markets with less stringent (or no) restrictions in place for financial stocks. While regulators have been successful in temporarily inflating prices, there is evidence that this has come at the cost of increased volatility and reduced liquidity.

3.6 Summary

While short-selling has long been a contentious issue, relatively little or no empirical evidence is available on the impact of short-sale restrictions on market quality. The 2008 short-sale bans provide an ideal setting for these tests because it provides a binding constraint. Thus, it is not necessary to rely on proxies for short-sale constraints, as in previous research. This chapter empirically examines the impact of the 2008 short-selling bans on the market quality of stocks subject to the bans. Thus, in doing so it examines whether the short-selling bans have achieved their desired outcomes. Using data from 14 equity markets, the market quality of financial stocks subject to the bans is examined by comparing to stocks not subject to the bans. Evidence indicates that restrictions on short-selling lead to artificially inflated prices, indicated by positive abnormal returns. This is consistent with Miller's (1977) overvaluation theory and suggests the bans have been effective in temporarily stabilising prices in struggling financial stocks. Market quality is reduced during the restrictions, as evidenced by wider bid-ask spreads, increased price volatility and reduced trading activity.

Table 3-9 Pooled cross-sectional regressions: No bans

This table reports pooled cross-sectional regression results from markets with no ban on short-selling for the following regression:

$$Y_{it} = \beta_{0t} + \beta_{1t}\,Period_i + \beta_{2t}\,Sample_i + \beta_{3t}\,Ban_i + \varepsilon_{it}$$

The pooled data include: both the treatment and control samples over the pre- (30 trading days prior to event) and post-event (30 trading days subsequent to event) period. If the ban was in place for less than 30 trading days, the duration of the ban is used as the post-event window. The treatment sample includes financial stocks. The control sample includes stocks from a major index in the corresponding market, excluding stocks in the treatment sample (see Table 3-2). Y_{it} is the market quality measure of interest for stock i during interval t. Market quality measures include: Spread (Relative bid-ask spread), Price volat. (Daily price volatility), Return volat. (Daily return volatility), Value (Daily turnover value) and Volume (Daily traded volume). Ban_i is a dummy variable equal to one if the stocks are subject to a short-selling ban, and zero otherwise. $Period_i$ is a control dummy variable equal to one if the observation lies in the post-event period, and zero otherwise. $Sample_i$ is a control dummy variable equal to one if the observation belongs to the treatment sample, and zero otherwise. The regressions include calendar-day dummy variables and stock dummy variables, and the standard errors take into account clustering by calendar date and clustering by stock (Thompson, 2009). *, **, and *** denote significance at the 10%, 5%, and 1% levels.

Market	Measure	Intercept	Period	Sample	Ban	R^2
Hong Kong	Spread	-5.962***	0.469***	0.609***	-0.073	0.51
	Price volat.	0.118***	0.069***	-0.022***	-0.006**	0.59
	Return volat.	-6.927***	-0.367	-1.454***	-0.317*	0.61
	Value	19.755***	0.131*	1.331***	0.100**	0.96
	Volume	18.164***	0.400***	1.921***	0.066	0.95
Sweden	Spread	-5.495***	0.180***	-0.405***	-0.018	0.61
	Price volat.	0.077***	0.048***	0.020***	0.013***	0.59
	Return volat.	-7.546***	1.044**	0.272	0.787***	0.60
	Value	20.842***	0.497***	0.159**	0.183***	0.89
	Volume	16.714***	0.654***	-0.276***	0.131**	0.92
Japan	Spread	-5.481***	0.664***	0.484***	-0.028	0.39
	Price volat.	0.048***	0.024***	0.011***	-0.001	0.50
	Return volat.	-6.800***	0.511**	0.483	-0.614	0.61
	Value	23.468***	0.011	0.148*	0.089***	0.92
	Volume	16.162***	0.159***	-0.168**	0.038	0.98

Chapter 4: The impact of naked short-selling on the securities lending and equity market

4.1 Introduction

The literature review examining the impact of short-selling in Chapter 2 shows that the existing literature investigates changes in the rules governing either covered short-sales (see Chang, Chang and Yu, 2007), or changes to short-sale constraints that affect both naked and covered short-sales (see Boehme, Danielsen and Sorescu, 2006). This is interesting as, despite the apparent assumption that naked short-selling is detrimental, relatively little or no empirical evidence is available on the impact that naked short-selling has on financial markets. The purpose of this chapter is to bridge this gap in the literature by directly examining the impact of allowing *naked* short-selling on returns, volatility and liquidity. This opportunity is provided by a unique feature of the Australian Securities Exchange (ASX) which allows naked short-sales for certain securities on an approved short-sale list that is revised over time.[26] The addition of a security to the designated list of eligible stocks represents a shift from *only* allowing covered short-sales to allowing *both* covered and naked short-sales,

[26] Securities are added or removed from the list based on market capitalisation, shares issued and liquidity. See Section 4.3.1 for further detail.

thus allowing an isolation of the impact of permitting naked short-sales on financial markets.

The remainder of this chapter is organised as follows. Section 4.2 uses the literature reviewed in Chapter 2 to develop several hypotheses that are tested in this chapter. Section 4.3 describes the institutional details for short-sales on the ASX. Section 4.4 reports the data, sample selection and the empirical analysis of the impact of naked short-selling on returns, liquidity and volatility. Section 4.5 provides a summary of the main results and concludes the chapter.

4.2 Hypothesis development

This section uses the literature reviewed in Chapter 2 to develop several hypotheses that are tested in this chapter. As discussed in Section 3.2, the disagreement models (e.g., Miller, 1977) predict that short-sale constraints prevent pessimists from taking bearish positions in constrained stocks. The addition of a security to the designated list of eligible stocks represents a shift from *only* allowing covered short-sales to allowing *both* covered and naked short-sales. This shift to naked short-selling may circumvent the fee charged by the stock lender, which represents a significant cost associated with covered short-selling.[27] In addition to this direct cost, there are several risks associated with covered short-selling, including the risk of a short squeeze due to

[27] Naked short-sellers at the time of sale have not borrowed or entered into an agreement to borrow the stock and may repurchase the stock without incurring the borrowing fee. The Australian Securities Lending Association Limited estimates that these costs can range between 25 and 400 basis points, representing a significant barrier to covered short-sales. See Section 4.3.1 for further detail.

an involuntarily closure of the stock loan (the short-seller is unable to find an alternative supply of stock in the event that the loan is closed). Further, naked short-selling circumvents search costs associated with locating and negotiating securities for lending. Together, these costs and risks represent a short-sale constraint which could be removed when naked short-sales are permitted.

Miller's (1977) overvaluation theory predicts positive abnormal returns when short-sale constraints are imposed. Conversely, when short-sale constraints are lifted, (i.e., addition of a security to the designated list of eligible stocks), it could be expected that any overvaluation would be reversed through the presence of negative abnormal returns. Therefore the following hypothesis is tested:

Hypothesis$_{4,1}$: *Securities added to the designated list of eligible stocks experience negative abnormal returns.*

As discussed in Section 3.2, the theoretical evidence provides conflicting predictions regarding the impact of short-sales on volatility. The same arguments apply here, except that this chapter specifically examines the impact of naked short-sales. Differences between the behaviour of naked and covered short-sellers may lead to the impact of allowing naked short-sales on returns and volatility to differ from that of covered short-sales. While not academically documented, naked short-sales are often associated with market manipulation.[28] To the extent that naked short-sellers may

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[28] Naked short-selling is often associated with market manipulation in the financial press. Examples include articles published in the *Wall Street Journal* and *Financial Times* (see Crittenden and Scannell, 2009 and Shapiro, 2008).

engage in the downward manipulation of stock prices, one could expect their trades to increase stock price volatility. Given the impact of allowing naked short-selling is yet to be examined, the following hypothesis is tested:

Hypothesis$_{4,2}$: *Securities added to the designated list of eligible stocks experience increases in stock price/return volatility.*

As discussed in Section 3.2, the limited theory suggests that short-sale constraints could worsen market liquidity (Diamond and Verrecchia, 1987). Conversely, one could expect that the removal of a short-sale constraint would lead to an increase in liquidity. As discussed in Chapter 2, there is little empirical or theoretical evidence on how short-sale constraints affect liquidity. Given the limited empirical literature, further evidence is required regarding the impact of short-selling on market liquidity. Further, naked short-sale constraints could affect the mix of passive and active strategies of short-sellers, which could in turn affect liquidity measures such as bid-ask spreads and order-depth. Therefore the following hypothesis is tested:

Hypothesis$_{4,3}$: *Securities added to the designated list of eligible stocks experience an increase in liquidity.*

4.3 Institutional settings

4.3.1 Short-selling regulation on the ASX

Short-sales in Australia are governed by both Section 1020b of the Corporations Act 2001 and Section 19 of the ASX Market Rules. Section 19.3 of the market rules restricts naked short-sales to a group of securities listed on the approved short-sale products.[29] The ASX market rules require that securities meet the following minimum requirements to be included in the designated list of eligible stocks: market capitalisation of $100 million; 50 million shares on issue; and possess 'sufficient liquidity'. The ASX considers 7.5% volume-based liquidity in the preceding three months as 'sufficient liquidity' for the purposes of these rules.[30] Based on discussions with exchange officials, the requirement of a minimum market capitalisation of $100 million is strictly adhered to.[31] However, while the minimum requirements for market capitalisation are followed, the ASX does exercise discretion with regard to 'sufficient liquidity' and may form the opinion that a lower or higher level of volume-based liquidity is sufficient in a particular circumstance. Therefore the process of being added to the list is primarily driven by market capitalisation and the ASX does not exercise discretion unless stocks meet this minimum market capitalisation.

The designated list of eligible stocks is maintained by the ASX and is 'usually' revised on a monthly basis. However, there is not always an addition event that occurs

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[29] On September 22, 2008, the ASX imposed a ban on naked short-sales concurrent with the Australian Securities and Investment Commission ban on covered short-sales.

[30] Volume-based liquidity is measured as the total volume traded as a percentage of the total amount of shares on issue. To be considered 'sufficient liquidity' the stock must have traded 7.5% of the total shares on issue in the preceding three months.

[31] This is confirmed in the sample, with all stocks meeting this minimum requirement.

every month and there may not be any changes to the list when it is revised. Similar to additions to the list, the ASX may also delete stocks from the list if they no longer meet its minimum requirements or the ASX exercises discretion with respect to the sufficient liquidity requirement. While access to these deletion events is available, only additions are examined because deletion events are often associated with negative news regarding the deleted stocks. Discussions with exchange officials reveal deletion events are less frequent and are often associated with securities that are delisted or in extreme financial distress. The announcement and implementation of additions to the list are made simultaneously in most cases or on the previous trading day.

4.3.2 Mechanics of short-selling on the ASX

On the ASX, when a covered short-sale occurs, the trader borrows securities from a securities lender and enters into an agreement to return them on demand. At the time of sale, arrangements are in place for delivery of the securities and the trader then sells the stock and delivers the shares to a buyer on settlement (T+3). While the position is open the lender requires collateral and no separate fee is payable for the loan.[32] This collateral (usually the proceeds from the sale) earns interest payable to the borrower at less than a normal market rate (rebate rate). The spread between the

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32 According to the Australian Securities Lending Association Limited, current market practice in Australia generally is that the collateral should be maintained within the range of at least 102-105% for equities secured by cash collateral, 110%-130% in the case of non-cash collateral and 0-2% for debt securities such as Government and semi-government bonds and inscribed stock. The value of the borrowed securities is marked to market daily. Collateral is commonly in the form of cash but may also be in the form of securities or occasionally irrevocable standby letters of credit. For further detail on securities lending in Australia see 'An Introduction to Securities Lending (Australia)' available at www.asla.com.au.

normal market rate and the rebate rate is the 'lending fee' which the lender earns and the borrower pays. When closing a position the trader buys back equivalent shares in the market and returns them to the stock lender. The collateral is then returned to the borrower plus interest earned at the rebate rate. There is no set time frame on how long a covered short position can be held, provided the lender does not recall the stock and the trader can meet the margin requirements.

A naked short-sale is where the participant, either proprietary or on behalf of a client, enters an order in the market and does not have in place arrangements for delivery of the securities. This differs slightly from the US where naked short-sales generally imply selling a stock short without borrowing it and subsequently failing to deliver the stock at settlement (Putniņš, 2009). When conducting a naked short-sale on the ASX, the trader must either buy back the stock within a short time frame (usually on the same day), or arrange to borrow the stock before settlement (T+3). If the stock is bought back on the same day then naked short-sellers can avoid the cost of borrowing the stock ('lending fee') which is incurred by covered short-sellers. When this occurs the traders' broker will net off the sell and buy order in the same stock and the trader will only pay/receive the difference upon settlement. However, if the naked short-seller does not buy back the stock on the same trading day, they must borrow the stock and deposit the sale proceeds as collateral, thus incurring a lending fee.

If the trader does not meet settlement their broker will incur fail fees (for each day they fail to meet settlement), which are then passed onto the client (brokers may also add administration fees). The fail fee charged to the broker is calculated as 0.10% of the value of the shortfall subject to a minimum fail fee of $50 and a maximum fail fee of $2,000.[33] For example, a naked short-sale worth $100,000 would incur a fail fee of $100 for each day the seller fails to deliver. However, more serious cases of settlement delays may also result in referral to the ASX disciplinary tribunal, which has the power to impose further fines. For example, the disciplinary tribunal recently fined Findlay & Co Stockbrokers Limited $30,000 for a failure to settle (i.e. by T+3) nine trades with a combined value of $391,953.00, between 8 October, 2007 and 19 October, 2007. The duration of the nine trades ranged from one to ten days past the T+3 obligation. However the ASX has no set guidelines on what constitutes a settlement delay that warrants further action.

While there is no minimum timeframe that a securities lender will lend stocks for covered short-selling, the fail fees and potential further fines limit the duration of naked short-sales such that a naked short-seller, on average, could have a shorter term horizon compared to a covered short-seller. This suggests that the strategies of naked short-sellers may be designed to take advantage of short term periods of market volatility, while covered short-sales could be used for longer term market corrections. The decision to employ naked or covered short-selling could also be a function of the relative cost of either strategy. Naked short-selling provides the opportunity to mitigate search costs and lending fees, however fail fees and potential fines can be incurred. Depending on the expected duration of the trade, short-sellers must determine if the lending costs are greater than the potential fail fees.

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[33] With effect from 1 September, 2008, the minimum and maximum fees applied in respect of fails are set at $100 and $5,000, respectively (with an *ad valorem* fee of 0.1 per cent). With effect from end-March 2009, participants are also required to close out any positions remaining unsettled on the fifth day after the trade date (i.e., T+5).

For example, if a short-seller expects to close out a trade within seven trading days they have two basic options. If a naked short-sale is placed, the trader does not incur any upfront costs (ignoring brokerage costs) but will incur fail fees for each day settlement is not met. In addition, the trader also risks further fines if the position is left open. In contrast, if a covered short-sale is placed the trader incurs the lending fee for the duration of the trade. If the lending fees are higher than the fail fees, naked short-selling may be more attractive, provided they expect to meet settlement shortly after T+3 and avoid any further fines. Alternatively if the lending fees are lower than the fail fees, covered short-selling may be preferred due to the lower costs. The expected duration of the short-sale, stock lending fees, fail fees and fines all influence the relative attractiveness of naked and covered short-selling.

4.4 Empirical analysis

Historical versions of the designated list of eligible stocks are obtained from the ASX to compile a sample of 317 additions over the period January 1, 2000 to December 31, 2007.[34] The final sample of 317 excludes events where either return and/or turnover data are not available for at least 180 trading days in the pre- and post-event periods, or there was a reversal of the short-sale constraint in the post-event period.[35] Reuters intraday data, provided by the Securities Industry Research Centre of Asia Pacific (SIRCA), are also used. The original data consist of trade level variables for all stocks

[34] Prior to September 22, 2008, the ASX reported the designated list of eligible stocks, containing all securities approved for naked short-sales, on its website daily. The approved list comprised 444 securities as at December 31, 2007.

[35] Fourteen events were excluded where there was a reversal of the short-sale constraint in the post-event period.

listed on the ASX from January 1, 2000 to September 28, 2008. Each transaction is matched with its corresponding liquidity-related variables such as prevailing bid-ask quotes and quoted depth. The sample includes 317 events, which are clustered around 32 event dates. The spread of 32 event dates (clusters) over the sample period minimises potential confounding effects of other concurrent events.

4.4.1 Impact on stock returns

Miller's (1977) overvaluation theory suggests that when short-sale constraints are removed (a stock is added to the designated list of eligible stocks) any overvaluation should be reversed, as demonstrated by negative abnormal returns. If restricting naked short-sales is a short-sale constraint, then lifting naked short-sale constraints should be associated with negative abnormal returns. This theory is outlined by hypothesis one ($H_{4,1}$). To test the first hypothesis, cumulative abnormal returns (CARs) are examined around the effective date for additions to the designated list of eligible stocks. Consistent with previous literature (Danielson and Sorescu, 2001, and Chang, Chang and Yu, 2007), effective dates rather than announcement dates are used as they represent the actual removal of short-sale constraints. Further, announcement dates are not available and discussions with exchange officials indicate changes are announced either on the effective date or one to two trading days in advance.

Cumulative abnormal returns (CARs) are calculated using the market-adjusted model defined as:

$$CAR_i^a(t_1, t_2) = \sum_{t=t_1}^{t_2} (R_{it} - R_{Mt}), \tag{4.1}$$

where R_{it} is stock i's return in interval t, and R_{Mt} is the return on the S&P/ASX All Ordinaries index in interval t.[36] While many studies use the market model (based on a pre-event back window), market-adjusted returns are used as they do not rely on a pre-event window to estimate abnormal returns. Using the market model, CARs observed in the post-event period (when naked short-sales are allowed) may occur because stocks added to the designated list of eligible stocks experience strong positive returns in the pre-estimation period (i.e., -280, -61), which ultimately lead to their addition to the designated list of eligible stocks. Therefore, the market model may generate misleading CARs in the post-event period due to the positive intercept term. The market-adjusted model does not suffer from this bias, performing well under a number of circumstances and better than more complex methods (Brown and Warner, 1985).

Following Chang, Chang and Yu (2007), significance testing of the CARs is conducted using a bootstrap procedure. This method is preferred over the usual event study t-tests as the stocks added to the designated list of eligible stocks tend to be of similar market capitalisation and liquidity. Thus, returns could have common components that are not considered under the market-adjusted model. These conditions may induce cross-sectional correlations among the CARs of individual stocks. To ensure that significance tests are not influenced by these potential

[36] S&P/ASX All Ordinaries index represents the 500 largest companies in the Australian equities market.

misspecifications, bootstrap tests are performed with actual security returns data to generate empirical distributions for various CARs under the null hypothesis specific to the model. These empirical distributions are used to gauge the significance of the respective CARs. The procedure is as follows:

1. Identify the number of clusters and number of stocks in each cluster.
2. Assign each cluster a random event date during the sample period January 1, 2000 to September 28, 2008.
3. On this date, form the 'pool' of eligible stocks (size and turnover).[37]
4. Randomly select from the pool the exact number of stocks in the cluster.
5. Combine clusters together to form a simulated sample.
6. Calculate CARs for the simulated sample.
7. Repeat for 1,000 samples, to generate empirical approximation of distribution of CARs.
8. Generate one-tailed empirical p-value by calculating the percentage of CARs observed in the empirical distribution based on 1,000 runs that is less than the average CAR values observed for the actual sample.

Table 4-1 reports CARs calculated using the market-adjusted model around the event date (the effective date is denoted day 0) for various windows before and after all events. The pre-event period is not associated with any significant abnormal returns

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[37] Specifically, the largest and smallest size percentiles and the highest and lowest annual turnover of the actual firms in the cluster are used as the upper and lower bounds. All the listed stocks whose size and annual turnover at that time fall between the bounds in the pool are then included. Chang, Chang and Yu (2007) highlight that because the chosen stocks for each cluster share a common event date, and because they are similar in terms of size and turnover to the stocks in the actual cluster, the abnormal returns, if any, of the chosen stocks would preserve the cross-sectional correlation as it exists in the actual cluster.

with the exception of the day preceding the event date (-1). As mentioned previously, announcements are made on the effective day or the previous trading day. The average abnormal return on day -1 is negative (-0.0674%) and significant at the 10% level using the bootstrapped p-values. While not strong in economic and statistical significance, this may suggest that some announcements occur prior to the effective date and that the market reacts to these announcements. The average abnormal return on the effective date (day 0) is -0.1856%, which is significant at the 5% level. While consistent with hypothesis one ($H_{4,1}$) and Miller's (1977) theory and suggesting some overvaluation is reversed when naked short-sales are allowed; this result is minor in terms of economic significance. Further, the result is restricted to the event date and does not persist with positive and insignificant CARs following the event date. For example, the CAR from day 0 through day 10 (0.7447%) is positive and insignificant (*p*-value=0.61).

The insignificant results may be driven a lack of short-sale constraints or dispersion of opinions in stocks added to the list. Miller's (1977) overvaluation argument is contingent on two necessary conditions: (1) presence of a short-sale constraint, and (2) a dispersion of investor opinions about the security's value. To test this, proxies for dispersion of investor opinion are required along with a measure of the short-sale constraint present in these stocks. Following Chang, Chang and Yu (2007), dispersion of investor opinion is measured using SIGMA, computed as the standard deviation of the daily raw returns in the pre-event window (-280, -61).[38] Jones and Lamont (2002)

[38] TURNOVER, computed as daily trading volume, scaled by shares outstanding, averaged over the pre-event window (-280, -61), is also used as a proxy for dispersion of opinion. Results are presented in the additional test in Table 4-8 in Section 4.4.1.

suggest that the securities lending fee (rebate rate) is the most appropriate variable for measuring the level of short-sale constraints. Data Explorers proprietary database is utilised to captures the lending fee on the Australian securities lending market.[39]

The data contain information from a significant number of the largest custodians in the industry and, by their own estimates, capture approximately 80% of the market for equity lending. This data contains lending information at a daily frequency over the period July 3, 2006 to May 27, 2008. While this does not cover the entire sample (317 events), it encompasses 87% (277 events) of the sample. The lending fee is expressed in undisclosed fee buckets ranging from 0-5, with 0 the cheapest to borrow and 5 the most expensive. The average fee for the 10 trading days leading into the event (-10,-1) is calculated to provide a measure of the level of short-sale constraint present in each stock before naked short-sales are allowed.

Using the lending fee, stocks are grouped into quartiles based on the level of short-sale constraint. Quartile one contains stocks that are least constrained (lowest lending fees) and quartile four contains stocks most heavily constrained (highest lending fees). The average of the lending fee bucket in quartile one to quartile four is 0.86, 1.22, 1.91 and 3.01, respectively. The median of the lending fee bucket in quartile one to quartile four is 0.70, 1.06, 1.97 and 3.10, respectively. The standard deviation of the lending fee bucket in quartile one to quartile four is 0.75, 0.54, 0.53 and 0.97, respectively. While specific information on the actual lending fees is not available, the

[39] http://dataexplorers.com

summary statistics demonstrate there is variation across the lending fee buckets and stocks in quartile four are more constrained than stocks in quartile one.

Similarly, using SIGMA as a proxy for dispersion of opinion, stocks are grouped into quartiles of dispersion of opinion. Quartile one contains stocks with the lowest dispersion of opinion, and quartile four contains stocks with the highest dispersion of opinion. Miller's (1977) model implies that there should only be negative abnormal returns on stocks added to the short-sale list which have a high dispersion of investor opinion *and* a significant short-sale constraint. To test this, Table 4-1 reports CARs for the following categories of stocks: highest constraint and dispersion quartile (High constraint and high dispersion); highest constraint and lowest dispersion quartile (High constraint and low Dispersion); lowest constraint and dispersion quartile (Low constraint and low dispersion); and lowest constraint and highest dispersion quartile (Low constraint and high dispersion).

Table 4-1 Cumulative abnormal returns around additions

This table reports cumulative abnormal returns based on the market-adjusted model around additions. An addition event is defined as one in which an individual stock is added to the list and is eligible for naked short-sales from the event day, denoted as day 0. Using the lending fee, stocks are grouped into quartiles based on the level of short-sale constraint. Quartile one contains stocks that are least constrained (lowest lending fees) and quartile four contains stocks most heavily constrained (highest lending fees). Similarly, using SIGMA as a proxy for dispersion of opinion, stocks are grouped into quartiles of dispersion of opinion. Quartile one contains stocks with the lowest dispersion of opinion, and quartile four contains stocks with the highest dispersion of opinion. The one-tailed p-value is obtained by calculating the percentage of the mean abnormal returns observed in the bootstrapped empirical distribution, based on 1,000 runs, that is less than the average cumulative abnormal return values observed for the actual sample. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Full sample		High constraint and high dispersion		High constraint and low dispersion		Low constraint and low dispersion		Low constraint and high dispersion	
Event window (days)	Mean (%)	One-tailed p-value	Mean (%)	One-tailed p-value	Mean (%)	One-tailed p-value	Mean (%)	One-tailed p-value	Mean (%)	One-tailed p-value
(-10,-1)	0.9479	0.51	2.1690	0.83	0.6729	0.64	0.0140	0.92	3.1948	0.90
(-5,-1)	0.5904	0.90	0.6361	0.76	0.9489	0.20	-1.1758	0.23	1.4972	0.90
(-2,-1)	-0.0513	0.29	-0.4508	0.82	0.3491	0.44	-0.6503	0.27	-1.0307	0.42
-1	-0.0674*	0.10	-1.9531**	0.02	-0.0966	0.81	-0.5519	0.28	1.0011	0.73
0	-0.1856**	0.04	-3.4148***	0.00	-0.9419	0.20	0.3684	0.32	-1.7660*	0.08
(0,1)	0.1121	0.79	-1.4343	0.50	-1.0733	0.20	0.0725	0.91	-2.4190	0.30
(0,5)	0.4772	0.42	-0.4352	0.95	-1.3128	0.44	0.2123	0.84	0.5038	0.30
(0,10)	0.7447	0.61	-3.1976*	0.10	-4.6953	0.25	-0.0921	0.90	0.4304	0.95

Consistent with Miller (1977), stocks with the highest dispersion of opinion and highest short-sale constraint are the only stocks to exhibit significant and negative abnormal returns in the post-event period. These stocks experience a -3.4148% abnormal return on the event date, significant at the 1% level. Similar to the entire sample, the average abnormal return on the day preceding the event (-1) is negative (-1.9531%) and significant at the 5% level. This provides further evidence that the announcement of a change in short-sale constraints could lead to a price reaction prior to the event date. For the other categories in Table 4-1, the results are all insignificant except the highest dispersion and lowest constraint category where the abnormal return on the event date (-1.7660%) is negative and marginally significant at the 10% level. This result demonstrates that the impact of naked short-selling is limited to stocks that are the most constrained and have the highest dispersion of opinion. Together, the results in Table 4-1 provide support for hypothesis one ($H_{4,1}$), as shown by negative abnormal returns when naked short-sale constraints are lifted. This result is further confirmed by the increase in the magnitude (and significance) of the abnormal returns when stocks are most constrained and have the highest dispersion of opinion.

4.4.2 Impact on volatility and liquidity

To examine changes in volatility and liquidity, 60 trading days prior (subsequent) to the addition of a stock to the designated list of eligible stocks is selected as the pre-event period (post-event period). The decision to include stocks on the designated list of eligible stocks which are relatively large and actively traded reflects the ASX's attempt to avoid the claimed adverse influence of naked short-sales on smaller and less liquid stocks. However, this may result in a certain degree of endogeneity in the analysis as the addition of a security stems from past performance. In an attempt to address this concern and to control for market-wide changes in trading activity and liquidity, both matching and regression discontinuity design methodologies are employed.

4.4.2.1 Matching

A market capitalisation and dollar volume matched sample is constructed from control stocks that are not on the designated list of eligible stocks. The control sample is constructed by first creating a pool of stocks which are not on the designated list of eligible stocks. From this pool, a control stock for each treatment stock is selected on the same date by requiring the market capitalisation of the control stock to be within 10% of the treatment stock and then finding the stock which minimises the difference between the trading value ($) of the treatment and control stock on the last trading day before the event.[40] Previous studies that match based on size and trading activity include Mayhew, Sarin and Shastri (1995) and Bennet and Wei (2006).

To test whether volatility and liquidity measures change significantly for treatment stocks relative to control stocks, the difference between the pre- and post-averages for each variable (labelled Difference) in both the treatment and control samples is

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40 This matching is also conducted using average trading value ($) of the treatment and control stock on the last 20 trading days before the event. The results are presented in the additional tests in Tables 4-11 and Table 4-12.

calculated. The difference of the difference between the treatment and control samples (labelled Difference-in-difference) is then estimated. Statistical significance of both measures is determined using the Wilcoxon rank sum test. To minimise the possibility of cross correlation due to clustering, the cross-sectional average of all events in each cluster is examined.

4.4.2.2 Regression discontinuity design

While the matching methodology attempts to control for market-wide changes, the control stocks by definition will be smaller in size (market capitalisation) than the treatment sample. Further, the matching method may not control for possible reversals in liquidity/volatility. For example, any post-event reduction observed in volatility/liquidity may result from a reversal of abnormally high volatility/liquidity in the pre-event period. Thus, a regression discontinuity (RD) design is employed to estimate the impact of allowing naked short-selling on equity markets. The main idea of this method is to exploit a unique feature of the ASX (naked short-sales are allowed on stocks exceeding 100 million in market capitalisation) to obtain a reliable estimate of the effect of allowing naked short-selling on volatility and liquidity. For stocks on the opposite side of the discontinuity point (100 million in market capitalisation), their underlying characteristics should be very similar, yet they have differing short-sale constraints. Thus the difference in volatility/liquidity should be driven predominantly by the difference in short-sale constraints.

The program evaluation literature documents that RD design is used to obtain reliable estimates of causal effects (Hahn, Todd and Van Der Klaauw, 2001, and Imbens and Lemieux, 2008). Recently, several studies in economics apply and extend RD design methods, including Black (1999), Angrist and Lavy (1999), Van Der Klaauw (2002), DiNardo and Lee (2004), Chay and Greenstone (2005), Chay, McEwan, Urquiola (2005) and Lee (2008). For example, Angrist and Lavy (1999) examine the effect of class size on students' performance and Van Der Klaauw (2002) analyses the effects of financial aid on college enrolment. RD design is increasing in use as it can identify the causal effects under much weaker assumptions, while standard methods that deal with an endogeneity problem usually rely on assumptions of exclusion restrictions, distribution of error terms, or a conditional independence assumption (Lee and Lemieux, 2009). The key feature of the RD design is that treatment is given to individuals only if an observed covariate crosses a known threshold. Thus under weak smoothness conditions, the probability of receiving treatment near the cut-off behaves as if random. This feature helps to identify the causal effect without imposing arbitrary exclusion restrictions, functional forms, or distributional assumptions on error terms.

RD design is used where assignment to the treatment D (equal to 1 if naked short-selling is allowed and 0 otherwise) is determined by the value of a covariate, X_i (market capitalisation), being on either side of the discontinuity point, c (100 million in market capitalisation). Local linear regressions provide a non-parametric way of consistently estimating the treatment effect in an RD design (Hahn, Todd and Van Der Klaauw, 2001). Following Imbens and Lemieux (2008), a rectangular kernel is used which amounts to estimating a standard regression, where Y_i is the outcome variable from the treatment, over a window of width h on both sides of the discontinuity value (100 million in market capitalisation). Further, the discontinuity value c is subtracted from the covariate X_i (market capitalisation), i.e., transform X_i to $X_i - c$. The outcome variable, Y_i, is calculated as the change in the measure of interest (i.e., volatility or liquidity)

$$Y_i = \frac{Y_{post(0,60)} - Y_{pre(-60,-1)}}{Y_{pre(-60,-1)}}, \tag{4.2}$$

where $Y_{post(0,60)}$ and $Y_{pre(-60,-1)}$ represent the average measure of interest in the post- and pre-event period surrounding each event.[41] This measure is used as the outcome variable as it captures the average change in liquidity/volatility when naked short-sales are allowed. Rather than estimating two separate regressions on either side of the discontinuity point, Imbens and Lemieux (2008) document that the average treatment effect (τ) can be estimated directly in a single pooled regression of both sides of the discontinuity point by solving:

$$\min_{\alpha,\beta,\tau,y} \sum_{i=1}^{N} 1\{c-h \le X_i \le c+h\} \cdot (Y_i - \alpha - \beta \cdot (X_i - c) - \tau \cdot D_i - y \cdot (X_{i-c}) \cdot D)^2. \tag{4.3}$$

The advantage of the pooled approach is that it directly yields estimates and standard errors of the treatment effect τ. Standard errors are adjusted using a variance/covariance matrix that is robust to clustering with respect to the event date (Petersen, 2009). The interaction term between D and X is included to allow the

[41] Consistent with the matching analysis, the pre- and post-event windows are 60 trading days.

regression function to differ on both sides of the discontinuity point (Imbens and Lemieux, 2008). To address the potential concern of a temporary effect or reversal in liquidity/volatility, an additional variable is incorporated. The additional variable, denoted Z_i, is the change in the measure of interest (i.e., volatility or liquidity) calculated as

$$Z_i = \frac{Z_{pre(-5,\,0)} - Z_{pre(-65,\,-60)}}{Z_{pre(-65,\,-60)}}, \tag{4.4}$$

where $Z_{pre(-5,0)}$ is the average measure of interest in the five trading days leading into an event and $Z_{pre(-65,60)}$ is the average measure of interest in the five trading days prior to the pre-event window. Z_i captures the average change in liquidity/volatility over the pre-event period. Following Imbens and Lemieux (2008), the additional variable is incorporated and the average treatment effect is estimated by solving:

$$\begin{aligned} \min_{\alpha,\beta,\tau,y} \sum_{i=1}^{N} 1\{c-h \le X_i \le c+h\} \cdot (Y_i - \alpha - \beta \cdot (X_i - c) \\ - \tau \cdot D_i - y \cdot (X_i - c) \cdot D - \delta' Z_i)^2. \end{aligned} \tag{4.5}$$

An important issue when implementing the RD design is the choice of window width *h* around the discontinuity point (i.e., the choice of bandwidth). This determines how many stocks will be included in the regressions based on their market capitalisation. For example, a bandwidth of 0.20 would equate to a window width, *h*, of $20 million ($100 million*0.20) and would restrict the analysis to stocks with a market capitalisation between $80 million and $120 million. A larger bandwidth yields more precise estimates as more observations are available to estimate the regression. However, the linear specification is less likely to be accurate when a larger bandwidth is used, which can bias the estimate of the treatment effect. The rule-of-thumb (ROT) and cross-validation methods are two common approaches for estimating bandwidths (Lee and Lemieux, 2009).[42]

The bandwidth is estimated using both procedures, with both yielding similar results. The ROT procedure suggests an optimal bandwidth of 0.45, while the cross-validation procedure suggests an optimal bandwidth of 0.53. Based on these results, analysis is conducted using a 0.50 bandwidth. Therefore the RD analysis is conducted on stocks in the matched sample with a market capitalisation between $50 and $150 million.[43]

4.4.2.3 Variable measurement

To examine the impact of naked short-sales on volatility, a variety of trade-by-trade, 15-minute interval and daily volatility measures are estimated. Daily measures include: (i) Classic = [ln (closing price on day t / closing price on day t-1)] ^{2}; (ii) G-K estimator;[44] and (iii) H-L, calculated as ln (daily high / daily low). Interval (15-minute) measures include: (i) Sum Ret^2, calculated as the sum of the squared interval returns; and (ii) H-L, calculated as ln (interval high / interval low). Trade-by-trade

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[42] For detailed explanation of the rule-of-thumb (ROT) and cross-validation procedures see Fan and Gijbels (1996) and Imbens and Lemieux (2008), respectively.

[43] Further analysis is conducted using various bandwidths ranging from 0.25 to 0.75. The results using a bandwidth of 0.25 are presented in the additional tests in Section 4.4.3.

[44] $\text{G-K estimator} = 0.511(a-b)^2 - 0.019\left[x(a+b) - 2ab\right] - 0.383x^2$, where x = ln (Daily close price / Daily open price), a = ln (Daily high price / Daily open price) and b = ln (Daily low price / Daily open price). G-K estimator was developed by Garman and Klass (1980), and takes into account the joint effects of the opening and closing price.

volatility, denoted Trade-Volatility, is calculated as the standard deviation of trade-to-trade returns.

To examine the impact on liquidity of the change in naked short-sale constraints, five measures of liquidity are examined. The first is the relative bid-ask spread, calculated as the quoted bid-ask spread (difference between prevailing best bid and ask quotes), divided by the prevailing quote midpoint. Relative bid-ask spreads are used as they control for stock price variation, both over time and across stocks. Harris (1994) suggests order depth is a vital component of liquidity not captured by bid-ask spreads. Subsequently limit order depth is measured as the combined dollar value of orders at the prevailing best bid and ask quotes.

To provide a more comprehensive measure of liquidity, the effective spread is calculated by firstly classifying each trade as either buyer- or seller-initiated using the method described in Ellis, Michaely and O'Hara (2000). Consistent with Goldstein and Kavajecz (2000) and Jones and Lipson (2001), the midpoint of the prevailing quotes immediately prior to each trade is used as the pre-trade benchmark. The effective spread is calculated as the percentage return from the pre-trade benchmark to the trade price. As part of the analysis of liquidity, trading activity is also examined by calculating Turnover (%), measured as daily trading volume divided by shares outstanding, and Turnover value, measured as the dollar value of daily trading volume.

4.4.2.4 Return volatility

Table 4-2 reports statistics for pre- and post-event return volatility for both treatment and control samples. Across all measures, volatility increases for the treatment sample in the post-event period, represented by the positive values in the treatment Difference column. Over the same period, volatility for control stocks either decreases or is insignificant across all measures. Most importantly, the Difference-in-difference column, which reports the Difference between the 'Difference' for the treatment and control samples, is positive and significant across all measures at the 5% level. This is consistent with the second hypothesis ($H_{4,2}$) and suggests that allowing naked short-selling leads to elevated levels of stock price/return volatility at both the intraday and daily levels.

The magnitude of these results varies across the different volatility measures. At the daily level, the Classic and G-K measures of volatility experience an increase of 0.0106 and 0.0026, respectively, over the event period. While the difference may seem minor, this represents a 12.31% and 4.94% increase in the Classic and G-K measures of volatility, respectively. After controlling for the changes in the control sample, the difference-in-difference changes are 14.51% and 2.28%, respectively. Consistently, the intraday (Sum return2) and Trade-volatility measures experience 4.67% and 6.16% increases, respectively.

The two price range volatility measures, Daily H-L and 15-minute H-L, both experience smaller increases over the event period. After controlling for the changes in the control sample, the difference-in-difference changes are 1.82% and 1.01%, respectively. The magnitude of these changes can be quantified for any given stock price. The daily H-L measure in the pre-event period is 2.8751%; this implies that the log of daily high over daily low equals 0.028751. Therefore the high/low price ratio is 1.02916, and for a stock with a $20 daily low, this would represent an average price range of 58.33 cents in a trading day. Given the measure increases by 1.82%, this represents a 1.06 cent increase in the daily price range. This interpretation suggests that the price range measures experience slight increases in volatility when naked short-sales are allowed. However, the remaining measures experience a minimum of 2.28%, and up to 12.31%, increase in volatility.

Table 4-3 reports estimates of the average treatment effect, from the RD analysis, for various volatility measures. The key variable, *D*, captures the marginal impact of allowing naked short-selling on stock return volatility. Results are homogenous across all volatility measures, with the coefficient, *D,* positive and statistically significant at the 5% level. Consistent with the matching analysis and the second hypothesis ($H_{4,2}$), using a more robust method (RD design) and controlling for a potential temporary effect or reversal in volatility, allowing *naked* short-sales increases volatility which is consistent with the introduction of *covered* short-sales (see Chang, Chang and Yu, 2007).

The magnitude of these results appears to differ from the results of the matching in Table 4-2. For example, the 15-minute H-L treatment effect (Difference-in-difference) is 0.0015 in Table 4-2, which differs from the treatment effect (τ) of 0.4913 in Table 3. The differences arise due to the following reasons. Firstly, the dependent variables in the regressions are a percentage increase in the variable of interest. This measure is calculated for both the treatment and control samples and pooled regressions are conducted where the average treatment effect (τ) is captured by the coefficient of the dummy variable (D, 1 if naked short-selling is allowed and 0 otherwise). The average treatment effect (τ) captures the difference between percentage changes in the treatment and control samples in percentage terms, rather than difference changes. Further, the regressions control for other factors not taken into account in Table 4-2, such as the pre-event changes in the variable of interest and market capitalisation.

4.4.2.5 Liquidity

Table 4-4 reports statistics for pre- and post-event trading activity and liquidity measures for both the treatment and control samples. The impact of naked short-sales on trading activity differs in direction between the two measures. Turnover (%) is positive and insignificant when naked short-sales are allowed (difference-in-difference, 0.0005), while Turnover value is negative and insignificant when naked short-sales are allowed (difference-in-difference, -231.41). The result of the matching suggests that trading-based liquidity, as measured by Turnover value and Turnover (%), is not significantly altered by changes in naked short-selling constraints.

Relative bid-ask spreads increase significantly in the post-event period for the treatment sample, and the Difference-in-difference is positive and significant at the 1% level. Economically, relative bid-ask spreads increase from an average of 80.61 basis points in the pre-event period to 87.01 basis points when naked short-sales are allowed. After controlling for changes in the control sample, relative bid-ask spreads increase by an average of 3.91 basis points, which represents a 4.85% increase. This represents a one cent increase in the spread for a stock trading at $25 (equivalent to the minimum tick).

While relative bid-ask spreads suggest that execution costs increased, order depth difference-in-difference is positive and significant (at the 5% level), suggesting execution costs decrease when naked short-sales are allowed. However, the increase in order depth does not always signify a decrease in liquidity or transaction costs when the bid-ask spread has widened. The impact on execution costs is generally unclear when there is an increase in both bid-ask spreads and quoted depth. If the increase in bid-ask spreads dominates, then execution costs are likely to rise. If the increase in quoted depth is more significant, then execution costs could decrease.

The effective spread is a more robust measure of execution costs that takes into account both order depth and bid-ask spreads. The effective spread results from Table 4-4 document a significant increase in the treatment sample, while the change in the control sample is insignificant. The increase in the effective spread indicates that execution costs are higher after naked short-selling is allowed, suggesting that the increase in bid-ask spreads dominates the increase in quoted depth. Together, the results of the matching analysis suggest that allowing naked short-sales impairs market liquidity via an increase in transaction costs. This is inconsistent with hypothesis three ($H_{4,3}$); however, in terms of magnitude, caution is urged in interpreting these results, as this represents an increase of 0.17% after controlling for changes in the control sample.

Table 4-2 Matching statistics: Volatility

This table reports various volatility measures for both the treatment and control sample. The treatment sample includes stocks where an addition event occurs. An addition event is defined as one in which an individual stock is added to the list and is eligible for naked short-sales from the event day, denoted as day 0. The control sample includes stocks matched to the treatment sample based on market capitalisation and trading value. Volatility variables include: daily measures (Classic, G-K estimator and H-L); Intraday 15-minute interval measures (Sum Ret^2 and H-L); and Trade-by-trade measures (Trade-Volatility). The Pre and Post columns represent the cross-sectional average of each variable for the pre- (60 trading days prior to event) and post-event (60 trading days subsequent to event) period. The Difference column reports the difference between the Pre and Post averages for each variable in both the treatment and control samples. The Difference-in-difference column reports the difference of the difference between the treatment and control samples. Statistical significance of the differences (Difference and Difference-in-difference) is conducted using the Wilcoxon rank sum test. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

		Treatment			Control			
Interval	Volatility measure	Pre	Post	Difference	Pre	Post	Difference	Difference-in-difference
Daily	Classic	0.0861	0.0967	0.0106***	0.0828	0.0809	-0.0019*	0.0125***
	G-K	0.0526	0.0552	0.0026*	0.0482	0.0496	0.0014	0.0012**
	H-L	2.8751	2.9443	0.0692***	2.6319	2.6487	0.0168	0.0524**
15-minute	Sum return2	0.0557	0.0590	0.0033**	0.0555	0.0563	0.0007	0.0026***
	H-L	0.1487	0.1533	0.0045**	0.1427	0.1457	0.0030	0.0015**
Trade	Trade-volatility	0.4367	0.4517	0.0150***	0.4977	0.4858	-0.0119*	0.0269**

Table 4-3 Regression discontinuity design statistics: Volatility

This table reports regression discontinuity results, calculated by solving $\min_{\alpha,\beta,\tau,y} \sum_{i=1}^{N} 1\{c - h \leq X_i \leq c + h\} \cdot (Y_i - \alpha - \beta \cdot (X_i - c) - \tau \cdot D_i - y \cdot (X_i - c) \cdot D - \delta' Z_i)^2$ using local linear regressions where Y_i is the outcome variable from the treatment, over a window of width h on both sides of the discontinuity value (100 million in market capitalisation). The outcome variable, Y_i, is calculated as the change in the volatility measure of interest $Y_i = \frac{Y_{post(0,60)} - Y_{pre(-60,-1)}}{Y_{pre(-60,-1)}}$, where $Y_{post(0,60)}$ and $Y_{pre(-60,-1)}$ represent the average measure of interest in the post- and pre-event period surrounding each event. Zi is the change in the measure of volatility calculated as $Z_i = \frac{Z_{pre(-5,0)} - Z_{pre(-65,-60)}}{Z_{pre(-65,-60)}}$, where $Z_{pre(-5,0)}$ is the average measure of interest in the five trading days leading into an event and $Z_{pre(-65,60)}$ is the average measure of interest in the five trading days prior to the pre-event window. D (equal to 1 if naked short-selling is allowed, and 0 otherwise) is determined by the value of a covariate, X_i (market capitalisation), being on either side of the discontinuity point, c (100 million in market capitalisation). τ represents the average treatment effect. Pooled data includes both the treatment and control sample. The treatment sample includes stocks where an addition event occurs. An addition event is defined as one in which an individual stock is added to the list and is eligible for naked short-sales from the event day, denoted as day 0. The control sample includes stocks matched to the treatment sample based on market capitalisation and trading value. A bandwidth of 0.50 is applied which restricts the analysis to stocks in the matched sample with a market capitalisation between \$50 and \$150 million. Volatility variables include: daily measures (Classic, G-K estimator and H-L); intraday 15-minute interval measures (Sum Ret^2 and H-L); and trade-by-trade measures (Trade-Volatility). Standard errors are adjusted using a variance/covariance matrix that is robust to clustering with respect to event date (Petersen, 2009). *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively, with t-statistics presented in parentheses.

	Dependent variable: Y_i					
	Daily			15-minute		Trade
Independent variables	Classic	G-K	H-L	Sum return2	H-L	Trade-volatility
α	-0.3288**	-0.3925***	-0.3019***	-0.3795***	-0.3779*	-0.0185
	(-1.84)	*(-4.53)*	*(-3.18)*	*(-2.38)*	*(-1.78)*	*(-0.21)*
τ	0.4432**	0.3251***	0.3172***	0.4045**	0.4913**	0.1446**
	(2.25)	*(4.18)*	*(3.20)*	*(2.27)*	*(2.34)*	*(1.91)*
β	<0.0001*	<0.0001***	<0.0001**	<0.0001	<0.0001*	<0.0001
	(-1.74)	*(-3.68)*	*(-1.85)*	*(-1.47)*	*(-1.67)*	*(-0.53)*
y	<0.0001*	<0.0001***	<0.0001**	<0.0001	<0.0001*	<0.0001
	(-1.74)	*(-3.68)*	*(-1.85)*	*(-1.47)*	*(-1.67)*	*(-0.53)*
δ'	0.0488	0.1897***	0.1683***	0.1731**	0.0222	0.1276**
	(0.63)	*(3.22)*	*(3.67)*	*(2.06)*	*(0.28)*	*(2.03)*
Adjusted R^2	0.08	0.10	0.13	0.07	0.08	0.16

Table 4-4 Matching statistics: Trading activity and liquidity

This table reports various trading activity and liquidity measures for both the treatment and control sample. The treatment sample includes stocks where an addition event occurs. An addition event is defined as one in which an individual stock is added to the list and is eligible for naked short-sales from the event day, denoted as day 0. The control sample includes stocks matched to the treatment sample based on market capitalisation and trading value. Liquidity variables include: Turnover, measured as total volume traded divided by total number of shares on issue; Turnover value, measured as the dollar value of traded volume; Effective spread, measured as the percentage return from the pre-trade benchmark to the trade price; Relative bid-ask spread, calculated as the quoted bid-ask spread (difference between prevailing best bid and ask quotes), divided by the prevailing quote midpoint; and Order depth, calculated as the dollar volume at the prevailing best bid and ask quotes. The Pre and Post columns represent the cross-sectional average of each variable for the pre- (60 trading days prior to event) and post-event (60 trading days subsequent to event) period. The Difference column reports the difference between the Pre and Post averages for each variable in both the treatment and control samples. The Difference-in-difference column reports the difference of the difference between the treatment and control samples. Statistical significance of the differences (Difference and Difference-in-difference) is conducted using the Wilcoxon rank sum test. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Treatment			Control			
Measure	Pre	Post	Difference	Pre	Post	Difference	Difference-in-difference
Turnover (%)	0.3095	0.2693	-0.0402***	0.2582	0.2174	-0.0407***	0.0005
Turnover value ($'000)	3,890.27	3,624.27	-266.00	3,126.02	3,091.42	-34.59	-231.41
Relative bid-ask spreads (%)	0.8061	0.8701	0.0640***	0.8915	0.9164	0.0249*	0.0391***
Order depth ($'000)	342.39	366.54	24.15*	314.13	289.57	-24.57*	48.72**
Effective spread (%)	0.4048	0.4062	0.0014***	0.4568	0.4564	-0.0003	0.0017***

Table 4-5 reports estimates of the average treatment effect, from the RD analysis, on various trading activity and liquidity measures. Results for both trading activity measures document an increase in trading activity, with the coefficient, *D,* positive and statistically significant at the 1% level. These results, contrary to the matching analysis, suggest that allowing naked short-selling significantly increases trade-based liquidity. Consistent with the matching analysis, allowing naked short-sales results in increased relative bid-ask spreads, order depth and effective spreads. This again suggests that the increase in bid-ask spreads dominates the increase in quoted depth. Therefore, using a more robust method (RD design) and controlling for a potential temporary effect or reversal in liquidity, liquidity is impaired (execution costs increase) when naked short-selling is allowed.

4.4.2.6 Components of the bid-ask spread

The previous section highlights a significant reduction in the level of liquidity when naked short-sale constraints are removed. There are several explanations why allowing naked short-sales could impair liquidity. It can be argued that naked short-sellers, like all short-sellers, are on average informed traders (Diamond and Verrecchia, 1987, and Boehmer, Jones and Zhang, 2008). Allowing naked short-sales will lead to increased information asymmetry and an increase in the adverse selection component of the bid-ask spread. To examine whether this is consistent with an increase in the adverse selection component of the spread, the adverse selection cost component of the bid-ask spread is estimated using the method developed in Lin, Sanger and Booth (1995) and subsequently applied to an electronic limit order market in Brockman and Chung (1999). The adverse selection component is calculated by estimating the following regression for each event over both the pre- and post-event periods:

$$\Delta Q_{t+1} = \lambda z_t + e_{t+1} \tag{4.6}$$

where Q is the natural log of the bid-ask spread midpoint, z is the natural log of the difference between the transaction price and the bid-ask spread midpoint and e is a normally distributed error term. The coefficient of z, λ, measures the adverse selection component of the bid-ask spread. Table 4-6 presents summary statistics of the adverse selection cost component, before and after naked short-sales are allowed. Results indicate that the adverse selection component of the bid-ask spread increases by 6.70% when naked short-sale constraints are removed. This result is significant at the 1% level when assessed using both a two-sample *t*-test and Wilcoxon rank sum test.

To control for market-wide changes that may be driving the increase in the adverse selection component of the spread, the adverse selection component of the spread is estimated for the control sample. The results, also in Table 4-6, document that the adverse selection component of the spread falls by 1.35%, statistically significant at the 5% level. This suggests that the increase in adverse selection component of the bid-ask spread cannot be attributed to a market-wide increase. These results are consistent with the theory that naked short-sellers, on average, are informed or price destabilisers and subsequently, when naked short-sales are allowed, the adverse selection component of the bid-ask spread increases.

Table 4-5 Regression discontinuity design statistics: Trading activity and liquidity

This table reports regression discontinuity results, calculated by solving $\min_{\alpha,\beta,\tau,y} \sum_{i=1}^{N} 1\{c-h \le X_i \le c+h\} \cdot (Y_i - \alpha - \beta \cdot (X_i - c) - \tau \cdot D_i - y \cdot (X_i - c) \cdot D - \delta' Z_i)^2$ using local linear regressions where Y_i is the outcome variable from the treatment, over a window of width h on both sides of the discontinuity value (100 million in market capitalisation). The outcome variable, Y_i, is calculated as the change in the volatility measure of interest $Y_i = \frac{Y_{post(0,60)} - Y_{pre(-60,-1)}}{Y_{pre(-60,-1)}}$, where $Y_{post(0,60)}$ and $Y_{pre(-60,-1)}$ represent the average measure of interest in the post- and pre-event period surrounding each event. Zi is the change in the measure of volatility calculated as $Z_i = \frac{Z_{pre(-5,0)} - Z_{pre(-65,-60)}}{Z_{pre(-65,-60)}}$, where $Z_{pre(-5,0)}$ is the average measure of interest in the five trading days leading into an event and $Z_{pre(-65,60)}$ is the average measure of interest in the five trading days prior to the pre-event window. D (equal to 1 if naked short-selling is allowed, and 0 otherwise) is determined by the value of a covariate, X_i (market capitalisation), being on either side of the discontinuity point, c (100 million in market capitalisation). τ represents the average treatment effect. Pooled data includes both the treatment and control sample. The treatment sample includes stocks where an addition event occurs. An addition event is defined as one in which an individual stock is added to the list and is eligible for naked short-sales from the event day, denoted as day 0. The control sample includes stocks matched to the treatment sample based on market capitalisation and trading value. A bandwidth of 0.50 is applied which restricts the analysis to stocks in the matched sample with a market capitalisation between $50 and $150 million. Liquidity variables include: Turnover, measured as total volume traded divided by total number of shares on issue; Turnover value, measured as the dollar value of traded volume; Effective spread, measured as the percentage return from the pre-trade benchmark to the trade price; Relative bid-ask spread, calculated as the quoted bid-ask spread (difference between prevailing best bid and ask quotes), divided by the prevailing quote midpoint; and Order depth, calculated as the dollar volume at the prevailing best bid and ask quotes. Standard errors are adjusted using a variance/covariance matrix that is robust to clustering with respect to event date (Petersen, 2009). *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively, with t-statistics presented in parentheses.

	Dependent variable: Y_i				
Independent variables	Turnover	Turnover value	Relative bid-ask spreads	Order depth	Effective spread
α	-0.6618***	-0.5594***	-0.0885	-0.2302***	-0.1022
	(-4.24)	*(-5.03)*	*(-0.91)*	*(-2.53)*	*(-1.08)*
τ	0.5184***	0.3716***	0.1801**	0.1558**	0.1936**
	(3.61)	*(3.01)*	*(1.99)*	*(1.89)*	*(2.17)*
β	<0.0001***	<0.0001**	<0.0001	<0.0001***	<0.0001
	(-2.62)	*(-2.18)*	*(-1.35)*	*(-2.62)*	*(-1.45)*
y	<0.0001***	<0.0001**	<0.0001	<0.0001***	<0.0001
	(-2.62)	*(-2.18)*	*(-1.35)*	*(-2.62)*	*(-1.45)*
δ'	0.2214***	0.1827***	0.1892***	0.1826***	0.1973***
	(3.12)	*(2.54)*	*(3.27)*	*(9.82)*	*(3.38)*
Adjusted R^2	0.10	0.05	0.16	0.22	0.17

Table 4-6 Adverse selection components of the bid-ask spread

This table reports the adverse selection component of the bid-ask spread, calculated following Lin, Sanger and Booth (1995), for both the treatment and control sample. The treatment sample includes stocks where an addition event occurs. An addition event is defined as one in which an individual stock is added to the list and is eligible for naked short-sales from the event day, denoted as day 0. The control sample includes stocks matched to the treatment sample based on market capitalisation and trading value. The Pre and Post columns represent the cross-sectional average of each variable for the pre- (60 trading days prior to event) and post-event (60 trading days subsequent to event) periods. Mean change represents the increase in the adverse selection cost from the pre- to the post-event period. Mean change (%) represents the percentage increase in the adverse selection cost from the pre- to the post-event period. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively, using a two-sample t-test. +, ++, and +++ denote significance at the 10%, 5%, and 1% levels, respectively, using a two-sample Wilcoxon rank-sum test.

	Treatment sample		Control sample	
	Pre	Post	Pre	Post
Mean	0.335	0.357	0.358	0.353
Mean change	0.022***+++		-0.005**++	
Mean change (%)	6.70***+++		-1.35**++	

4.4.3 Additional tests

4.4.3.1 Presence of options

Although the focus of this chapter is on the effect of short-sale constraints, it is well known that a short position can be replicated using derivatives such as exchange traded options.[45] Even though it is debatable whether derivatives reduce short-sale constraints in an economically meaningful way,[46] it is important to note that stocks in

[45] Figlewski and Webb (1993) find that constrained investors will buy puts and write calls as a substitute for short-selling.

[46] Mayhew and Mihov (2005) is part of an emerging wave of studies which document options do not reduce short-sale constraints. Other studies include: Mayhew and Mihov (2004), Ofek, Richardson and Whitelaw (2004), Lakonishok, Lee and Poteshman (2004), Brunnermeier and Nagel (2004),

this sample may have options listed. However, further investigation reveals that less than 2% of stocks in the sample have options listed (during the sample period). Further, it is important to note that the effect of listed options on sample stocks is likely to minimise the impact of changes to the designated list of eligible stocks, thereby reducing the magnitude of the results.

4.4.3.2 Securities lending market

A potential concern of this chapter is that the results are not attributable to the introduction of naked short-sales, but rather some other unobservable factor. Ideally, data on short-selling could be used to demonstrate short-sellers move from covered to naked short-selling, or that traders who previously did not trade begin naked short-selling when stocks are added to the designated list of eligible stocks. However, naked short-sales are not reported on the ASX and therefore data is impossible to collect. To examine this, a proprietary database provided by Data Explorers, which captures information on the Australian securities lending market, is further employed. From Data Explorers, information is obtained on the total value of borrowed securities (denoted as Borrowed value hereafter– a measure of the value of the securities that are currently borrowed), the total value of lendable assets (denoted as Inventory value hereafter– a measure of the value of the securities that custodians currently have available for lending), the percentage utilisation (denoted as Utl hereafter– the fraction of total lendable assets that are currently on loan) and the securities lending fee (denoted as Fee hereafter – the weighted average loan fee expressed in

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Lamont and Stein (2004), Battalio and Schultz (2006), Danielsen, Van Ness and Warr (2007) and Bris, Goetzmann and Zhu (2007).

undisclosed fee buckets ranging from 0-5, with 0 the cheapest to borrow and 5 the most expensive).

Changes in securities lending data are examined around changes to the designated list of eligible stocks. If there is a change in the short-selling market around the introduction of naked short-sales, a reduction in the demand for securities lending could be expected. To control for market-wide changes, the treatment and control samples are pooled together to estimate the following cross-sectional regressions for each day in the pre- and post-event periods surrounding each event:[47]

$$LendingVariable_{it} = \beta_{0t} + \beta_{1t}\, Period_i + \beta_{2t}\, Group_i + \beta_{3t}\, Shortable_i + \beta_{4t} Volume_{it} + \varepsilon_{it} \tag{4.7}$$

In the above model, $LendingVariable_{it}$ is the securities lending measure of interest for stock i during interval t. $Shortable_i$ is a dummy variable equal to one if stock i is eligible for naked short-sales, and zero otherwise. $Period_i$ is a control dummy variable equal to one if the observation lies in the post-event period, and zero otherwise. $Group_i$ is a control dummy variable equal to one if the observation belongs to the treatment sample, and zero otherwise. $Volume_{it,}$ represents trading volume for stock i during interval t, and controls for changes in trading activity which may affect short-sales activity. Standard errors are adjusted using a variance/covariance matrix that is robust to clustering with respect to both firm and event date (Thompson, 2009).

47 Consistent with the RD regressions, the regressions are conducted using 60 trading days as the pre- (and post-) period interval.

Table 4-7 presents results for the regressions using Borrowed value, Inventory value, Utl and Fee as the dependent variable. The key variable *Shortable*$_i$, which captures the marginal impact of allowing naked short-sales on the securities lending variables, is negative and statistically significant at the 10% level for both Borrowed value and Utl. This suggests there is a significant reduction in both the value and percentage of securities borrowed. Over the same period there is a significant reduction in the cost of borrowing securities (Fee) and no significant change in the value of inventory available for lending (Inventory value). The reduction in the average cost of borrowing is consistent with a decrease in demand for securities lending.

Together these results suggest that allowing naked short-sales leads to a significant reduction in the demand for securities lending. Given securities lending is a commonly used proxy for the level of covered short-sales (see D'Avolio, 2002), this implies that there is a significant reduction in the level of covered short-selling for stocks added to the designated list of eligible stocks. While the evidence is not conclusive, naked short-selling appears to occur once stocks are added to the list. Therefore, having controlled for exogenous factors, the results in this chapter can be attributed (at least in part) to the introduction of naked short-sales.

4.4.3.3 Dispersion of opinions

The results in Table 4-1 utilise SIGMA as a proxy for dispersion of opinion. Other studies utilise various measures for dispersion of opinion, including Boehme, Danielsen and Sorescu (2006), who utilise three measures of dispersion of opinions. The first uses analyst forecasts, the second volatility of stock returns and the third uses turnover. A measure based on analyst forecasts is intuitively appealing but suffers from limitations due to the need for at least two analysts to compute a value. The stocks in the sample typically have low coverage, with only one or two analysts covering these stocks. While a measure based on analyst forecasts could not be used, TURNOVER, computed as daily trading volume, scaled by shares outstanding, averaged over the pre-event window (-280, -61), is also used as a proxy for dispersion of opinion. Chang, Chang and Yu (2007) also use three measures which include two measures almost identical to the two measures used in this chapter. The first measure is a pre-event estimation period standard deviation of returns, the second is the standard deviation of the error terms from a market model in the estimation period and the third is a turnover measure in the estimation period. The second measure is not used due to the reliance on the market model, which, as discussed in Section 4.4.1, may lead to misleading results.

The results of the abnormal returns analysis conducted using TURNOVER as a proxy for dispersion of opinions are presented in Table 4-8. The results in Table 4-8 show that the conclusions drawn in Table 4-1 remain unchanged when using an alternative measure for dispersion of opinions. The results support identical conclusions, and support the first hypothesis.

4.4.3.4 RD analysis

A further potential concern with the results relates to the Regression Discontinuity (RD) design and the size of the bandwidth. Specifically, issues could arise due to the concern about comparing stocks with market capitalisation between 50 and 150 million. Therefore the analysis is conducted using a tighter bandwidth of 0.25 which examines stocks with market capitalisation between 75 and 125 million. The results of this analysis are presented in Table 4-9 and Table 4-10 and effectively replicate Tables 4-3 and 4-5 using a smaller bandwidth. The results remain qualitatively consistent with small changes in the magnitude and significance across different measures. Specifically, the results remain almost unchanged for the volatility and trading activity regressions. The reduction in bandwidth does however lead to a reduction in the magnitude and significance of the liquidity regressions. The coefficients remain significant at the 10% level but highlight that the changes in liquidity are smaller and less robust than the volatility and trading activity results.

4.4.3.5 Matching analysis

A further potential concern relates to the matching analysis based on the trading volume on the day prior to the addition event. If there is any leakage or mismeasurement of the announcement, this day could be problematic. To address this concern, the analysis is reconducted using the average dollar trading volume over 20 trading days rather than one day. The results of this analysis are presented in Table 4-11 and Table 4-12 and replicate Table 4-2 and Table 4-4. The results show that the results remain effectively similar, and do not alter any conclusions of the chapter.

4.4.3.6 Impact on volatility and liquidity: By lending fee quartile

To provide further evidence that the results in this study are related to naked short-selling, the impact of naked short-sales on volatility and liquidity is re-examined. Using the lending fee, stocks are grouped into quartiles based on the level of short-sale constraint. Quartile one contains stocks that are least constrained (lowest lending fees) and quartile four contains stocks most heavily constrained (highest lending fees). The RD regressions in Tables 4-3 and 4-5 are re-conducted by splitting the results into lending fee quartiles. As discussed in Section 4.3.2, the lending fee, along with the expected time frame of the short-sale, is a vital determinant in the decision to use naked or covered short-selling. Stocks in the lowest lending fee quartile should experience relatively little naked short-selling since covered short-selling is relatively less costly. If the results are related to naked short-selling, then the results should be concentrated in the high loan fee stocks.

Table 4-13 reports the average treatment effect (τ) from the RD regressions on the impact of naked short-selling on liquidity and volatility. For the purposes of brevity, the treatment effect is only reported for the highest fee quartile (highest constraint) and lowest fee quartile (lowest constraint). The results in Table 4-13 demonstrate that the direction of the results in both the low and high fee quartiles is consistent with the results in Tables 4-3 and 4-5. However, the magnitude and significance of the average treatment effect differs largely between the two groups. The low fee quartile results, while in the same direction, are smaller in magnitude and largely insignificant. In contrast, the high fee quartile results are larger in magnitude and more significant than the results in Tables 4-3 and 4-5. This suggests that the impact of naked short-selling is greater, both in magnitude and significance, for stocks with higher lending fees (more short-sale constrained). Stocks with relatively low lending fees experience smaller or no significant change from the introduction of naked short-sales. This is consistent with the notion that stocks with lower lending fees experience relatively little naked short-selling since covered short-selling is less expensive. Further, Table 4-13 also demonstrates that the results in this chapter appear to be related (at least in part) to the introduction of naked short-sales.

Table 4-7 Security lending around changes

This table reports pooled cross-sectional regression results of the following regressions:

$$LendingVariable_{it} = \beta_{0t} + \beta_{1t} Period_i + \beta_{2t} Group_i + \beta_{3t} Shortable_i + \beta_{4t} Volume_{it} + \varepsilon_{it}$$

The pooled data include: both the treatment and control samples over the pre- (60 trading days prior to event) and post-event periods (60 trading days subsequent to event). The treatment sample includes stocks where an addition event occurs. An addition event is defined as one in which an individual stock is added to the list and is eligible for naked short-sales from the event day, denoted as day 0. The control sample includes stocks matched to the treatment sample based on market capitalisation and trading value. $LendingVariable_{it}$ is the securities lending measure of interest for stock i during interval t. Lending variables include: Borrowed value, a measure of the value of the securities that are currently borrowed; Inventory value, a measure of the value of the securities that custodians currently have available for lending; Utl, the fraction of total lendable assets that are currently on loan; and Fee, expressed in undisclosed fee buckets ranging from 0-5, with 0 the cheapest to borrow and 5 the most expensive. $Volume_{it}$ is a control variable representing trading volume for stock i during the interval t. $Shortable_i$ is a dummy variable equal to one if the stock is eligible for naked short-sales, and zero otherwise. $Period_i$ is a control dummy variable equal to one if the observation lies in the post-event period, and zero otherwise. $Group_i$ is a control dummy variable equal to one if the observation belongs to the treatment sample, and zero otherwise. Standard errors are adjusted using a variance/covariance matrix that is robust to clustering with respect to both firm and event date (Thompson, 2009). *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively, with t-statistics presented in parentheses.

	Dependent variable: $LendingVariable_{it}$			
Independent variables	Borrowed value	Inventory value	Utl	Fee
Intercept	12.1910***	19.5780***	24.2910***	2.0690***
	(35.83)	*(38.38)*	*(77.19)*	*(120.91)*
Volume	<0.0001***	<0.0001***	<0.0001***	<0.0001***
	(13.49)	*(9.24)*	*(8.87)*	*(-12.59)*
Period	-0.1967	2.1254	-2.3537	0.0522
	(-0.43)	*(-0.43)*	*(-0.43)*	*(-0.43)*
Group	0.5891	0.5891***	0.5891*	0.5891***
	(1.30)	*(5.24)*	*(-1.82)*	*(-6.92)*
Shortable	-1.0501*	0.6927	-0.9012	-0.0754**
	(-1.71)	*(0.75)*	*(-1.58)*	*(-2.42)*
Adjusted R^2	0.02	0.01	0.02	0.02

Table 4-8 Cumulative abnormal returns around additions (alternate measure of dispersion of investor opinions)

This table reports cumulative abnormal returns based on the market-adjusted model around additions. An addition event is defined as one in which an individual stock is added to the list and is eligible for naked short-sales from the event day, denoted as day 0. Using the lending fee, stocks are grouped into quartiles based on the level of short-sale constraint. Quartile one contains stocks that are least constrained (lowest lending fees) and quartile four contains stocks most heavily constrained (highest lending fees). Similarly, using TURNOVER as a proxy for dispersion of opinion, stocks are grouped into quartiles of dispersion of opinion. Quartile one contains stocks with the lowest dispersion of opinion, and quartile four contains stocks with the highest dispersion of opinion. The one-tailed p-value is obtained by calculating the percentage of the mean abnormal returns observed in the bootstrapped empirical distribution, based on 1,000 runs, that is less than the average cumulative abnormal return values observed for the actual sample. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Full sample		High constraint and high dispersion		High constraint and low dispersion		Low constraint and low dispersion		Low constraint and high dispersion	
Event window (days)	Mean (%)	One-tailed p-value	Mean (%)	One-tailed p-value	Mean (%)	One-tailed p-value	Mean (%)	One-tailed p-value	Mean (%)	One-tailed p-value
(-10,-1)	0.9479	0.51	2.6214	0.85	0.6866	0.65	0.0143	0.94	3.2600	0.92
(-5,-1)	0.5904	0.90	0.6558	0.78	0.9782	0.21	-1.2122	0.24	1.5435	0.93
(-2,-1)	-0.0513	0.29	-0.4463	0.81	0.3456	0.44	-0.6439	0.27	-1.0205	0.42
-1	-0.0674*	0.10	-1.9726**	0.02	-0.0976	0.82	-0.5574	0.28	1.0111	0.74
0	-0.1856**	0.04	-3.5204***	0.00	-0.9710	0.21	0.3798	0.33	-1.8206*	0.08
(0,1)	0.1121	0.79	-1.4201	0.50	-1.0627	0.20	0.0718	0.90	-2.3950	0.30
(0,5)	0.4772	0.42	-0.4441	0.97	-1.3396	0.45	0.2166	0.86	0.5141	0.31
(0,10)	0.7447	0.61	-3.2965*	0.10	-4.8405	0.26	-0.0949	0.93	0.4437	0.98

Table 4-9 Regression discontinuity design statistics: Volatility (additional test)

This table reports regression discontinuity results, calculated by solving $\min_{\alpha,\beta,\tau,y} \sum_{i=1}^{N} 1\{c - h \le X_i \le c + h\} \cdot (Y_i - \alpha - \beta \cdot (X_i - c) - \tau \cdot D_i - y \cdot (X_{i-c}) \cdot D - \delta' Z_i)^2$ using local linear regressions where Y_i is the outcome variable from the treatment, over a window of width h on both sides of the discontinuity value (100 million in market capitalisation). The outcome variable, Y_i, is calculated as the change in the volatility measure of interest $Y_i = \frac{Y_{post(0,60)} - Y_{pre(-60,-1)}}{Y_{pre(-60,-1)}}$, where $Y_{post(0,60)}$ and $Y_{pre(-60,-1)}$ represent the average measure of interest in the post- and pre-event period surrounding each event. Zi is the change in the measure of volatility calculated as $Z_i = \frac{Z_{pre(-5,0)} - Z_{pre(-65,-60)}}{Z_{pre(-65,-60)}}$, where $Z_{pre(-5,0)}$ is the average measure of interest in the five trading days leading into an event and $Z_{pre(-65,60)}$ is the average measure of interest in the five trading days prior to the pre-event window. D (equal to 1 if naked short-selling is allowed, and 0 otherwise) is determined by the value of a covariate, X_i (market capitalisation), being on either side of the discontinuity point, c (100 million in market capitalisation). τ represents the average treatment effect. Pooled data includes both the treatment and control sample. The treatment sample includes stocks where an addition event occurs. An addition event is defined as one in which an individual stock is added to the list and is eligible for naked short-sales from the event day, denoted as day 0. The control sample includes stocks matched to the treatment sample based on market capitalisation and trading value. A bandwidth of 0.25 is applied which restricts the analysis to stocks in the matched sample with a market capitalisation between $75 and $125 million. Volatility variables include: daily measures (Classic, G-K estimator and H-L); intraday 15-minute interval measures (Sum Ret^2 and H-L); and trade-by-trade measures (Trade-Volatility). Standard errors are adjusted using a variance/covariance matrix that is robust to clustering with respect to event date (Petersen, 2009). *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively, with t-statistics presented in parentheses.

	Dependent Variable: Y_i					
	Daily			15-minute		Trade
Independent variables	Classic	G-K	H-L	Sum return^2	H-L	Trade-volatility
α	-0.5094***	-0.5661***	-0.3959***	-0.4939***	-0.5377***	0.0186
	(-2.35)	*(-3.73)*	*(-4.03)*	*(-2.51)*	*(-2.53)*	*(-0.18)*
τ	0.5873***	0.4598***	0.3915***	0.5557***	0.6267***	0.1112*
	(-2.39)	*(-3.05)*	*(-3.58)*	*(-2.55)*	*(-2.72)*	*(-1.73)*
β	<0.0001***	<0.0001***	<0.0001***	<0.0001**	<0.0001***	<0.0001
	(-2.87)	*(-2.67)*	*(-3.61)*	*(-2.06)*	*(-2.48)*	*(-0.08)*
y	<0.0001***	<0.0001***	<0.0001***	<0.0001**	<0.0001***	<0.0001
	(-3.29)	*(-2.81)*	*(-3.93)*	*(-1.96)*	*(-2.55)*	*(-0.32)*
δ'	0.0252	0.2042***	0.1468***	0.1410**	0.0490	0.1479***
	(-0.43)	*(-2.41)*	*(-5.05)*	*(-2.13)*	*(-0.65)*	*(-2.39)*
Adjusted R^2	0.10	0.12	0.19	0.11	0.08	0.10

Table 4-10 Regression discontinuity design statistics: Trading activity and liquidity (additional test)

This table reports regression discontinuity results, calculated by solving $\min_{\alpha,\beta,\tau,y} \sum_{i=1}^{N} 1\{c - h \le X_i \le c + h\} \cdot (Y_i - \alpha - \beta \cdot (X_i - c) - \tau \cdot D_i - y \cdot (X_i - c) \cdot D - \delta^{'} Z_i)^2$ using local linear regressions where Y_i is the outcome variable from the treatment, over a window of width h on both sides of the discontinuity value (100 million in market capitalisation). The outcome variable, Y_i, is calculated as the change in the volatility measure of interest $Y_i = \frac{Y_{post(0,60)} - Y_{pre(-60,-1)}}{Y_{pre(-60,-1)}}$, where $Y_{post(0,60)}$ and $Y_{pre(-60,-1)}$ represent the average measure of interest in the post- and pre-event period surrounding each event. Zi is the change in the measure of volatility calculated as $Z_i = \frac{Z_{pre(-5,0)} - Z_{pre(-65,-60)}}{Z_{pre(-65,-60)}}$, where $Z_{pre(-5,0)}$ is the average measure of interest in the five trading days leading into an event and $Z_{pre(-65,60)}$ is the average measure of interest in the five trading days prior to the pre-event window. D (equal to 1 if naked short-selling is allowed, and 0 otherwise) is determined by the value of a covariate, X_i (market capitalisation), being on either side of the discontinuity point, c (100 million in market capitalisation). τ represents the average treatment effect. Pooled data includes both the treatment and control sample. The treatment sample includes stocks where an addition event occurs. An addition event is defined as one in which an individual stock is added to the list and is eligible for naked short-sales from the event day, denoted as day 0. The control sample includes stocks matched to the treatment sample based on market capitalisation and trading value. A bandwidth of 0.25 is applied which restricts the analysis to stocks in the matched sample with a market capitalisation between \$75 and \$125 million. Liquidity variables include: Turnover, measured as total volume traded divided by total number of shares on issue; Turnover value, measured as the dollar value of traded volume; Effective spread, measured as the percentage return from the pre-trade benchmark to the trade price; Relative bid-ask spread, calculated as the quoted bid-ask spread (difference between prevailing best bid and ask quotes), divided by the prevailing quote midpoint; and Order depth, calculated as the dollar volume at the prevailing best bid and ask quotes. Standard errors are adjusted using a variance/covariance matrix that is robust to clustering with respect to event date (Petersen, 2009). *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively, with t-statistics presented in parentheses.

	Dependent variable: Y_i				
Independent variables	Turnover	Turnover value	Relative bid-ask spreads	Order depth	Effective spread
α	-0.7133***	-0.9423***	-0.0429	-0.2110**	-0.0549
	(-5.85)	*(-5.21)*	*(-0.43)*	*(-2.03)*	*(-0.57)*
τ	0.5306***	0.8110***	0.1451**	0.1330**	0.1524**
	(-3.57)	*(-3.81)*	*(-1.79)*	*(-1.68)*	*(-1.72)*
β	<0.0001***	<0.0001***	<0.0001	<0.0001	<0.0001
	(-3.78)	*(-4.01)*	*(-0.64)*	*(-1.42)*	*(-0.71)*
y	<0.0001***	<0.0001***	<0.0001	<0.0001	<0.0001
	(-4.01)	*(-4.18)*	*(-0.35)*	*(-1.49)*	*(-0.44)*
$\delta^{'}$	0.1751***	0.2576***	0.2103***	0.1982***	0.2219***
	(-2.85)	*(-3.09)*	*(-3.37)*	*(-8.32)*	*(-3.49)*
Adjusted R^2	0.15	0.23	0.10	0.21	0.10

Table 4-11 Matching statistics: Volatility (additional test)

This table reports various volatility measures for both the treatment and control samples. The treatment sample includes stocks where an addition event occurs. An addition event is defined as one in which an individual stock is added to the list and is eligible for naked short-sales from the event day, denoted as day 0. The control sample includes stocks matched to the treatment sample based on market capitalisation and trading value. Volatility variables include: daily measures (Classic, G-K estimator and H-L); Intraday 15-minute interval measures (Sum Ret^2 and H-L); and Trade-by-trade measures (Trade-Volatility). The Pre and Post columns represent the cross-sectional average of each variable for the pre- (60 trading days prior to event) and post-event (60 trading days subsequent to event) period. The Difference column reports the difference between the Pre and Post averages for each variable in both the treatment and control samples. The Difference-in-difference column reports the difference of the difference between the treatment and control samples. Statistical significance of the differences (Difference and Difference-in-difference) is conducted using the Wilcoxon rank sum test. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

		Treatment			Control			
Interval	Volatility measure	Pre	Post	Difference	Pre	Post	Difference	Difference-in-difference
Daily	Classic	0.0901	0.1035	0.0134***	0.0812	0.0792	-0.0020*	0.0154***
	G-K	0.0526	0.0550	0.0024*	0.0497	0.0513	0.0016	0.0008**
	H-L	2.7351	2.8062	0.0711***	2.6371	2.6542	0.0171*	0.0540***
15-minute	Sum return2	0.0562	0.0603	0.0041**	0.0578	0.0584	0.0006	0.0035**
	H-L	0.1511	0.1560	0.0049**	0.1433	0.1462	0.0029	0.0020**
Trade	Trade-volatility	0.4462	0.4624	0.0162***	0.5011	0.4890	-0.0121*	0.0283***

Table 4-12 Matching statistics: Trading activity and liquidity (additional test)

This table reports various trading activity and liquidity measures for both the treatment and control sample. The treatment sample includes stocks where an addition event occurs. An addition event is defined as one in which an individual stock is added to the list and is eligible for naked short-sales from the event day, denoted as day 0. The control sample includes stocks matched to the treatment sample based on market capitalisation and trading value. Liquidity variables include: Turnover, measured as total volume traded divided by total number of shares on issue; Turnover value, measured as the dollar value of traded volume; Effective spread, measured as the percentage return from the pre-trade benchmark to the trade price; Relative bid-ask spread, calculated as the quoted bid-ask spread (difference between prevailing best bid and ask quotes), divided by the prevailing quote midpoint; and Order depth, calculated as the dollar volume at the prevailing best bid and ask quotes. The Pre and Post columns represent the cross-sectional average of each variable for the pre- (60 trading days prior to event) and post-event (60 trading days subsequent to event) period. The Difference column reports the difference between the Pre and Post averages for each variable in both the treatment and control samples. The Difference-in-difference column reports the difference of the difference between the treatment and control samples. Statistical significance of the differences (Difference and Difference-in-difference) is conducted using the Wilcoxon rank sum test. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Treatment			Control			
Measure	Pre	Post	Difference	Pre	Post	Difference	Difference-in-difference
Turnover (%)	0.3121	0.2706	-0.0415***	0.2633	0.2223	-0.0410***	-0.0005
Turnover value ($'000)	3,780.37	3515.25	-265.12	3,133.14	3099.52	-33.62	-231.50
Relative bid-ask spreads (%)	0.8164	0.8839	0.0675***	0.8988	0.9221	0.0233*	0.0442***
Order depth ($'000)	343.52	367.48	23.96*	315.21	290.55	-24.66*	48.62**
Effective spread (%)	0.4011	0.4027	0.0016***	0.4678	0.4675	-0.0003	0.0019***

Table 4-13 Regression discontinuity design statistics by lending fee (additional test)

This table reports the average treatment effect (τ) from the regression discontinuity analysis calculated by solving $\min_{\alpha,\beta,\tau,y} \sum_{i=1}^{N} 1\{c-h \leq X_i \leq c+h\} \cdot (Y_i - \alpha - \beta \cdot (X_i - c) - \tau \cdot D_i - y \cdot (X_{i-c}) \cdot D - \delta' Z_i)^2$ using local linear regressions where Y_i is the outcome variable from the treatment, over a window of width h on both sides of the discontinuity value (100 million in market capitalization). The outcome variable, Y_i, is calculated as the change in the volatility measure of interest $Y_i = \frac{Y_{post(0,60)} - Y_{pre(-60,-1)}}{Y_{pre(-60,-1)}}$, where $Y_{post(0,60)}$ and $Y_{pre(-60,-1)}$ represent the average measure of interest in the post- and pre-event period surrounding each event. Zi is the change in the measure of volatility calculated as $Z_i = \frac{Z_{pre(-5,0)} - Z_{pre(-65,-60)}}{Z_{pre(-65,-60)}}$, where $Z_{pre(-5,0)}$ is the average measure of interest in the five trading days leading into an event and $Z_{pre(-65,60)}$ is the average measure of interest in the five trading days prior to the pre-event window. D (equal to 1 if naked short-selling is allowed and 0 otherwise) is determined by the value of a covariate, X_i (market capitalization), being on either side of the discontinuity point, c (100 million in market capitalization). Pooled data includes both the treatment and control sample. The treatment sample includes stocks where an addition event occurs. An addition event is defined as one in which an individual stock is added to the list and is eligible for naked short-sales from the event day, denoted as day 0. The control sample includes stocks matched to the treatment sample based on market capitalization and trading value. We apply a bandwidth of 0.50 which restricts our analysis to stocks in our matched sample with a market capitalization between \$50 and \$150 million. Using the lending fee, stocks are grouped into quartiles based on the level of short-sale constraint. Quartile one contains stocks that are least constrained (low fee) and quartile four contains stocks most heavily constrained (high fee). Only the Low fee (low constraint) and high fee (high constraint) quartiles are reported. Standard errors are adjusted using a variance/covariance matrix that is robust to clustering with respect to event date (Petersen, 2009). *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively with t-statistics presented in parentheses.

	Dependent Variable: Y_i										
	Volatility Measures					Liquidity Measures					
Treatment effect (τ)	Classic	G-K	Daily H-L	Sum Return^2	15-Min H-L	Trade Volatility	Turnover	Turnover Value	Relative Bid-ask spreads	Order Depth	Effective spread
Low fee	0.3132	0.2131*	0.2532**	0.2451	0.3032	0.1164	0.4145*	0.3121**	0.1423*	0.1256	0.1559*
	(1.49)	*(1.78)*	*(1.95)*	*(1.59)*	*(1.38)*	*(1.55)*	*(1.75)*	*(2.01)*	*(1.69)*	*(1.39)*	*(1.71)*
High fee	0.6431***	0.4551***	0.4497***	0.4955***	0.5486**	0.2164***	0.7422***	0.5162***	0.2316***	0.1911**	0.2644***
	(4.11)	*(6.82)*	*(4.99)*	*(3.81)*	*(1.98)*	*(2.55)*	*(5.19)*	*(4.36)*	*(4.59)*	*(1.99)*	*(4.71)*

4.5 Summary

The existing literature on the impact of short-selling examines changes in the rules governing either covered short-sales, or changes to short-sale constraints that affect both naked and covered short-sales. This chapter examines the impact of allowing *naked* short-selling on the securities lending and equity market in a unique market setting where naked short-sales are restricted to certain securities on an approved list. Consistent with Miller (1977), stocks with the highest dispersion of opinion and highest short-sale constraint are the only stocks to exhibit significant and negative abnormal returns in the post event period. These stocks experience a -3.4148% abnormal return on the event date, significant at the 1% level.

The impact of allowing naked short-selling on volatility and liquidity is examined using both a matching and regression discontinuity design. The results, consistent across both methods, reveal a small increase in the daily and intraday volatility of individual stock returns. Further, allowing naked short-selling leads to a small reduction in liquidity via increased transaction costs (wider bid-ask spreads and effective spreads). Further testing reveals that the impact of naked short-selling on market quality variables is greater, both in magnitude and significance, in stocks with higher short-sale constraints (higher lending fees). Stocks with relatively low short-sale constraints experience smaller or no significant change from the introduction of naked short-sales.

The increase in the bid-ask spread is attributed to an increase in the adverse selection component. This is consistent with the notion that short-sellers are likely to be informed traders. Analysis of the securities lending market reveals that the demand for securities lending is reduced following the introduction of naked short-selling. While the evidence is not conclusive, naked short-selling appears to occur once stocks are added to the designated list of eligible stocks.

Chapter 5: An empirical analysis of the relationship between credit default swap spreads and short-selling activity

5.1 Introduction

The literature examined in Section 2.4.4 uses a range of theoretical determinants of default risk to model CDS spreads. Benkert (2004), Greatrex (2009) and Ericsson, Jacobs and Oviedo (2009) document that individual firm CDS prices are related to risk-free interest rates, share prices, equity volatility, bond ratings and firm leverage. These studies suggest that theoretical determinants of default risk explain a significant amount of variation in CDS prices. Other studies incorporate new determinants to better explain the variation in CDS spreads. Zhang, Zhou and Zhu (2009) use theoretical determinants along with volatility and jump risk of individual firms from high-frequency equity prices to explain variation in CDS spreads. Cao, Yu and Zhong (2010) find that individual firms' put option-implied volatility is superior to historical volatility in explaining variation in CDS spreads. Tang and Yan (2007) find that measures of CDS liquidity are significant in explaining variation in CDS spreads.

This chapter extends this work by proposing a new measure of the likelihood of firm default - short-selling. By examining the relationship between CDS spreads and short-selling, this chapter adds to the existing literature which examines the determinants of CDS spreads and also adds to the existing literature on the information content of short-selling. The remainder of this chapter is organised as follows. Section 5.2 uses the literature reviewed in Chapter 2 to develop the main hypothesis tested in this chapter. Section 5.3 describes the data and determinants of CDS spreads. Section 5.4 describes the model specification and results of the empirical analysis. Section 5.5 provides a summary of the main results and concludes the chapter.

5.2 Hypothesis development

This section uses the literature reviewed in Chapter 2 to develop the main hypothesis tested in this chapter. Diamond and Verrecchia (1987) suggest that, since short-sellers do not have the use of sale proceeds, market participants never short-sell for liquidity reasons, which *ceteris paribus* implies relatively few uninformed short-sellers. Empirical studies confirm that heavily shorted stocks underperform, implying short-sellers are informed (see *inter alia* Desai, Ramesh, Thiagarajan and Balachandran, 2002, Jones and Lamont, 2002, Boehme, Danielson and Sorescu, 2006, Boehmer, Jones and Zhang, 2008, and Diether Lee and Werner, 2009a). Therefore short-sellers are informed traders who take positions by selling a company's stock in the expectation that prices will fall in the near future following the revelation of bad news specific to that firm. As such, the level of short-selling is a direct measure of the prospects for a company. High (low) short-selling indicates a more (less) pessimistic view of a company and an increased (decreased) likelihood of default. Therefore, CDS spreads should exhibit a positive and significant relationship to the level of short-selling. Thus, the main hypothesis tested in this chapter is:

Hypothesis$_{5,1}$: *CDS spreads are positively related to the level of short-selling*

5.3 Data

5.3.1 CDS

As CDSs for individual firms are traded over-the-counter, there is no central clearinghouse from which market activity is observed. Thus, early research typically uses limited samples of data, normally sourced from a sole market-maker. For example, Aunon-Nerin, Cossin, Hricko and Huang (2002) use CDS data from 'a major London interdealer broker', Benkert (2004) uses data from German bank WestLB and Hull, Predescu and White (2004) use data from derivatives broker, GFI. The use of data that captures only a subset of the market poses a problem as there is always a certain element of uncertainty as to how representative the research findings are. The availability of reliable data has improved with the emergence of Markit, a commercial data vendor that specialises in the CDS market. Markit currently collects price data from 40 of the major CDS price makers to create a comprehensive dataset that covers more than 3,000 corporate bond issuers. While this data is typically used by corporate clients to mark-to-market open CDS positions as well as to identify profitable capital structure arbitrage opportunities, a select number of researchers have been granted access to Markit data for the purposes of academic research (see *inter alia* Tang and Yan, 2007, Greatrex, 2009, Cao, Yu and Zhong, 2010, and Zhang, Zhou and Zhu, 2009).

In this chapter, information on CDSs is sourced from Markit. This proprietary database contains information on the CDS composite spread, the seniority of the underlying debt obligation, the currency and maturity of the contract and the average recovery rates used by data contributors in pricing each CDS contract. Following Zhang, Zhou and Zhu (2009), only US dollar-denominated five-year CDS contracts with modified restructuring (MR) clauses written on senior unsecured debt of US obligors are examined. While the contract maturity can range from six months to 30 years, the five-year maturity is the most commonly traded and is typically the focus of academic studies on CDS pricing (see *inter alia* Cao, Yu and Zhong, 2010). Rather than consider all CDSs, the subordinated class of contracts is eliminated as they represent only a small component of the database, with the majority of contracts written over senior unsecured obligations. Obligors in the financial, utility, and government sectors are also removed because of the difficulty in interpreting their capital structure variables. After examining the CDS spread data for outliers, observations are removed where large differences (above 20%) exist between the CDS spreads with MR clauses and those with full restricting clauses. Further, any observations with a CDS spread greater than 20% are removed. Zhang, Zhou and Zhu (2009) note that these observations are often associated with the absence of trading or a bilateral arrangement for upfront payment.

For each entity, the weekly CDS spread is sampled and the weekly recovery rates linked to end-of-week CDS spreads. After matching the CDS data with other information, such as short-selling, equity prices and balance sheet information (all discussed later), the final sample includes 330 firms. The sample period start date of 1 July, 2006 coincides with the beginning of the stock lending database. The sample period end date is set at 1 September, 2008, which is the beginning of the period of short-selling restrictions in the US. While the Markit database has CDS spreads data on a daily basis, weekly data is examined to avoid the use of stale CDS spreads and to minimise the effects of noise in the data. This still leaves sufficient observations to analyse data at the firm level (approximately 110 observations per firm in total).

5.3.2 Short-selling

As discussed in Section 5.2, short-sellers are informed traders who take positions by selling a company's stock in the expectation that prices will fall in the near future following the revelation of bad news specific to that firm. As such, the level of short-selling is a direct measure of the prospects for a company. High (low) short-selling indicates a more (less) pessimistic view of a company and an increased (decreased) likelihood of default. Therefore, CDS spreads should exhibit a positive and significant relationship to the level of short-selling.

Securities lending data is commonly used as a proxy for the level of short-sales (see D'Avolio, 2002),[48] and evidence suggests that it is closely correlated with actual

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[48] The use of securities lending market data is a new innovation in the literature, with only a few papers with access to this type of data, including D'Avolio (2002) and Diether, Lee and Werner (2008).

short-sales data.[49] Further, lending data allows for a more detailed examination of short-selling since it not only provides information on the demand for short-selling but also the supply. To this end, stock lending data is used as a proxy for short-selling. This data is sourced from the Data Explorers proprietary database, which captures information on the global securities lending market. The data contain information from a significant number of the largest custodians in the industry, and Data Explorers report that they capture approximately 80% of the market for stock lending.

The database provides daily security-level information on the supply-side (quantity of shares available for lending) and demand-side (volume information for loan transactions) of the lending market. Three measures related to short-selling that capture the demand and supply for short-selling are examined. The first measure, institutional ownership, captures the supply-side of the lending market and is measured as the total number of shares held by all beneficial owners divided by the total number of shares outstanding. The second measure, short interest, captures the demand-side of the lending market and is measured as the total number of shares lent, divided by the number of shares outstanding. The third measure, utilisation, incorporates the demand- and supply-side of the lending market and is measured as the amount of stock that is lent out for short-selling as a percentage of the total amount available for stock lending.

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[49] Data Explorers data includes lending for short-selling as well as borrowing for dividend arbitrage (typically to extract tax benefits through deals with foreign parties) and for settlement reasons (where a fund is unable to buy or sell a stock immediately, it must borrow the security). The majority of lending is for the purpose of short-selling, however, and Data Explorers reports that the correlation between the publicly reported level of short-interest in the US market and the Data Explorers estimate is almost 0.90. Berkman and McKenzie (2010) validate this finding.

5.3.3 Explanatory variables

To examine the effect of short-selling on CDS spreads, several explanatory variables are included to control for the fundamental determinants of credit risk. Following the previous literature, standard structural factors are incorporated, including firm-specific balance sheet information and macroeconomic variables, along with individual equity, rating and CDS contract information. These variables' hypothesised relationship and empirical specifications are outlined below.

Zhang, Zhou and Zhu (2009) specify the following firm-specific variables: leverage ratio, return on equity, and dividend payout ratio:

$$\text{Leverage ratio} = \frac{\text{Current debt} + \text{Long-term debt}}{\text{Total equity} + \text{Current debt} + \text{Long-term debt}}, \tag{5.1}$$

$$\text{Return on equity} = \frac{\text{Pretax income}}{\text{Total equity}}, \tag{5.2}$$

$$\text{Dividend payout ratio} = \frac{\text{Dividend payout per share}}{\text{Equity price}}, \tag{5.3}$$

The total equity and equity price are obtained from Datastream, with total equity measured using the number of shares outstanding and weekly share prices. Since other measures (i.e., Current Debt), obtained from Compustat, are only available at a quarterly level, the last available quarterly observation is collected and linear interpolation is used to obtain weekly estimates as in Collin-Dufresne, Goldstein and

Martin (2001). The use of weekly equity prices in the denominator of each measure also ensures variation on a weekly basis.

A firm's leverage ratio, which is central to all the structural form models, is expected to have a positive relationship with CDS spreads. The more levered the firm, the higher the probability of default. A firm's return on equity is expected to have a negative relationship with CDS spreads, as the probability of default is lower when the firm's profitability improves. A firm's dividend payout ratio is expected to have a positive relationship with CDS spreads, as a higher dividend payout ratio indicates a decrease in asset value; therefore, default is more likely to occur. Recovery rate is also included as an explanatory variable due to its effect on the present value of protection payments. For example, higher recovery rates reduce the present value of protection payments in the CDS contract.

Four macro-financial variables are also used: (1) the S&P 500 index average daily return (past six months), (2) the S&P 500 implied volatility index (VIX) from the option market, (3) the spot rate (average three-month Treasury rate), and (4) the slope of the yield curve (the 10-year rate minus the three-month rate). The S&P 500 index proxies for the overall state of the economy and improving market conditions should improve individual CDS spreads. Given individual firm value is a function of its business risk, which is, in turn, dependent on overall market conditions, a positive relationship is expected between the index level and individual spread levels.

Longstaff and Schwartz (1995) note that the static effect of a higher spot rate is to increase the risk-neutral drift of the firm value process. Given a higher drift reduces the probability of default, an increase in the spot rate (three-month Treasury rate) is expected to reduce credit spreads. Collin-Dufresne and Solnik (2001) note that although the spot rate is the only interest-rate-sensitive factor that appears in the firm value process, the spot rate process itself may depend upon the slope of the Treasury curve. If an increase in the slope of the Treasury curve increases the expected future short-term rate, then by the same argument as above, it should also lead to a decrease in credit spreads. Further, a steeper slope of the term structure is an indicator of improving economic activity in the future; it can also forecast an economic environment with a rising inflation rate and a tightening of monetary policy. Thus, CDS spreads should be inversely related to the slope of the yield curve (the 10-year rate minus the three-month rate).

In Merton's (1974) structural framework, equity is a call option on the underlying firm, while debt is similar to a put option. An increase in volatility should decrease the value of risky debt and increase CDS spreads. Intuitively, higher equity volatility often implies higher asset volatility; therefore, the firm value is more likely to hit below the default boundary. Using data from DataStream, historical volatility is estimated as the 250-day rolling variance of individual stock returns. The S&P 500 implied volatility (VIX) from the option market is also examined, as it captures the markets expectation of volatility.

Credit rating is shown to have explanatory power for credit spreads, even after controlling for the economic determinants of spreads (Fabozzi, Cheng and Chen, 2007). Credit rating is an opinion of the general creditworthiness of an obligor and its ability in the future to make timely payments on a specific fixed income security.

Therefore, the rating should directly reflect the probability of default and is expected to have a significant impact on CDS spreads. Ratings are reported using Standard and Poor's notation and reflect the average of the respective Standard and Poor's and Moody's ratings, or whichever rating was available if the company was not rated by both organisations. An inverse relationship between the quality of the respective borrower and the CDS spreads is expected. Dummy variables are included for all rating classes below AAA that are represented in the sample. The effect of the respective rating class is measured relative to a rating of AAA. There are no CDSs in the sample for firms rated worse than B.

5.4 Model specification and empirical results

The benchmark model is a pooled ordinary least-squares regression that estimates the average relationship between the dependent and independent variables across the entire database as:

$$CDS_{i,t} = \alpha + \beta_s Short\text{-}selling_{i,,t-1} + \beta_v \, Volatility_{i,,t-1} + \beta_r \, Rating_{i,,t-1} + \beta_m \, Macro_{i,,t-1} + \beta_f \, Firm_{i,,t-1} + \beta_r \, Recovery_{i,,t-1} + \varepsilon_{i,t} \quad (5.4)$$

where $CDS_{i,t}$ is the spread for stock i at time t, the explanatory variables are the vectors detailed in the previous section and $\varepsilon_{i,t}$ is the error term. Zhang, Zhou and Zhu (2009) note that most of the explanatory variables are jointly determined with CDS spreads which may artificially inflate the explanatory power of the model. To avoid this simultaneity problem, lagged explanatory variables are included in the model.

Standard errors are adjusted using a variance/covariance matrix that is robust to clustering with respect to both time and firm (Thompson, 2009). This approach is adopted to adjust for potential bias in OLS standard errors.

5.4.1 Summary statistics

Table 5-1 reports summary statistics for CDS spreads and the explanatory variables discussed in the previous section. The statistics are reported for the whole sample and divided into rating categories based on credit ratings. The CDS entities are concentrated in the BBB (47%), AAA to A (35%) and BBB and below (18%) categories. Consistent with previous findings, CDS spreads exhibit significant cross-sectional variation across the ratings categories. The highest-grade entities (AAA to A) have an average spread of 32.65 basis points (bps) compared to the lowest grade (BB and below) of 233.63 bps. Figure 5-1 shows that CDS spreads demonstrate significant time variation across the sample period (July 2006 to September 2008). There is an increase in CDS spreads that coincides with the onset of the GFC in June 2007, with CDS spreads more than doubling in the remainder of the sample period.

Short-interest, institutional ownership and utilisation, the measures relating to short-selling and main explanatory variables of interest, also demonstrate cross-sectional variation. Across the ratings, entities with the highest ratings (AAA to A) have an average short-interest of 1.89% compared to the lowest ratings (BB and below) which have an average short-interest of 8.06%. Similarly, entities with the highest ratings (AAA to A) have an average utilisation of 6.90% compared to the lowest ratings (BB and below) which have an average utilisation of 25.81%. Other explanatory variables behave as predicted by the literature. Leverage and volatility measures are lower for high-rating firms compared to low-rating firms, while return on equity and payout ratios are higher for high-rating firms compared to low-rating firms.

Figure 5-1 Five-year CDS spreads (basis points) by rating groups

The figure plots the weekly time series of average five-year CDS spreads for 330 entities with senior unsecured obligations with a modified restructuring clause from 1 July, 2006 to 1 September, 2008.

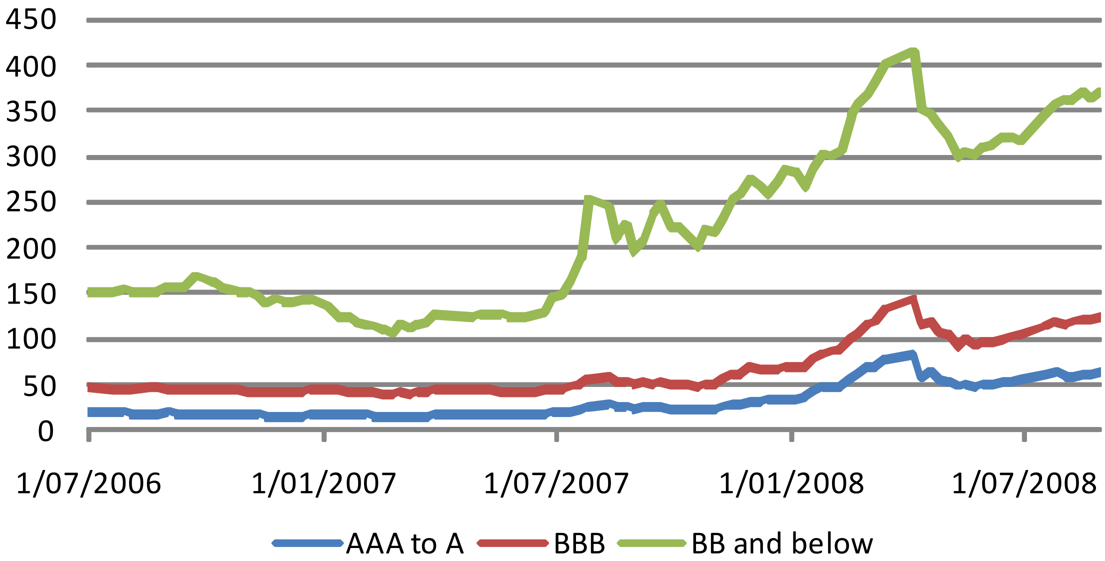

Table 5-1 Summary statistics

The table reports the summary statistics of all regression variables for the whole sample and three subgroups divided by credit ratings. The sample covers 330 entities over the period 1 July, 2006 to 1 September, 2008. Panel A reports the summary statistics of all firm-specific regression variables. These variables include five-year CDS spreads (CDS); recovery rates (Recovery) reported by Markit for senior unsecured obligations with modified restructuring clauses; firm-level equity return volatility (Historical volatility); firms' balance sheet information, including the leverage ratio, return on equity, and dividend payout ratio; and measures relating to short-selling, including the amount of stock that is lent out for short-selling as a percentage of the total amount available for stock lending (Utilisation), the total number of shares held by all beneficial owners divided by the total number of shares outstanding (Institutional ownership) and the total number of shares lent, divided by the number of shares outstanding (Short Interest). Panel B reports the summary statistics of the macro-financial variables: market return (S&P 500 return) and volatility (VIX); short-term rate (three-month Treasury rate); and slope (10-year Treasury rate minus three-month Treasury rate).

Panel A: Firm-specific variables

Credit rating category	AAA to A		BBB		BB and below		Whole sample	
Variable	Mean	Std dev	Mean	Std dev	Mean	Std dev	Mean	Std dev
CDS (bps)	32.65	28.04	65.21	61.51	233.63	192.98	77.21	107.97
Recovery (%)	39.81	0.70	39.68	0.98	40.46	3.97	39.84	1.72
Historical volatility (%)	1.47	0.49	1.69	0.57	2.30	0.85	1.70	0.65
Leverage (%)	16.55	11.99	22.54	13.70	35.76	20.75	22.24	15.60
Return on equity (%)	2.28	2.86	1.60	7.32	-1.62	16.16	1.39	8.25
Dividend payout ratio (%)	0.51	0.40	0.53	1.39	0.50	3.56	0.52	1.68
Short-interest (%)	1.89	2.46	3.13	3.99	8.06	7.41	3.38	4.67
Institutional ownership (%)	20.37	5.50	22.15	8.37	23.96	9.46	21.76	7.74
Utilisation (%)	6.90	9.83	12.93	17.44	25.81	22.09	12.57	17.08

Panel B: Macro-financial variables

	Mean	Std dev
S&P 500 return (%)	5.00	11.00
VIX (%)	18.21	5.80
3-Month Treasury rate (%)	3.73	1.41
Slope 10Y – 3M (%)	0.66	1.02

5.4.2 Univariate regression analysis

Prior to estimating multivariate regressions, the relationship between each individual explanatory variable and CDS spreads is estimated using OLS univariate regressions. The results are presented in Table 5-2 and are broadly consistent with previous literature. Specifically, the coefficients on the volatility measures (Historical and VIX) are positive and significant at the 1% level. Leverage and term spread exhibit a positive and significant relationship with CDS spreads, which is consistent with structural form models. Return on equity, spot rate and market return exhibit a negative and significant relationship with CDS spreads which is consistent with previous findings.

The key coefficients of interest, short-interest, institutional ownership and utilisation, are positive and significant when regressed against CDS spreads. This suggests that CDS spreads are positively related to the amount of short-selling as measured by short-interest. The positive coefficient on institutional ownership suggests that an increase in the amount of stock available for short-selling is associated with an increase in CDS spreads. Therefore the positive coefficient on short-interest may arise due to an increase in the amount of stock available for short-selling. However, the positive coefficient on utilisation suggests that increases in CDS spreads are associated with higher levels of short-selling rather than higher levels of institutional ownership. Table 5-2 shows that the variables which explain the greatest variation in CDS spreads are those predicted by the structural form models along with short-interest. In particular, short-interest, leverage and historical volatility regressions have the highest R^2 of 28%, 27% and 32%, respectively.

5.4.3 Multivariate analysis

While the univariate analysis in Table 5-2 documents that CDS spreads are positively related to short-selling, these regressions do not control for the theoretical determinants of CDS spreads. In Table 5-3, the results of the multivariate OLS regressions are reported. The regressions are first conducted using only rating dummy variables; firm-specific (excluding short-selling related measures) and macro-financial variables are then added before short-selling related measures are added separately in the final three regressions. Regression 1 shows that credit rating is an important determinant of CDS spreads. Consistent with previous studies (i.e., Zhang, Zhou and Zhu, 2009), firms with low credit ratings exhibit higher CDS spreads compared to high-rating firms. The R^2 (39%) shows that credit ratings alone can explain a large amount of variation in CDS spreads.

In Regression 2, all the explanatory variables (excluding short-selling related measures) are added to the rating dummy variables. The directions are consistent with the theoretical predictions and extant empirical evidence. Regression 2, in Table 5-3, documents that the coefficient on the spot rate (average three-month Treasury rate) is negative and significant at the 5% level. This is consistent with previous evidence from corporate bond yield spreads (see *inter alia* Duffie, 1999) and CDS spreads (see *inter alia* Cao, Yu and Zhong, 2010). The coefficient on the slope of the yield curve (the 10-year rate minus the three-month rate) is positive but insignificant. This differs from the univariate regressions in Table 5-2, where the coefficient is positive and highly significant. This suggests that when examined in a multivariate framework, controlling for other factors, its explanatory power diminishes and the explanatory power of the slope is subsumed by other explanatory variables.

Consistent with the univariate results, the coefficients on the volatility measures (Historical and VIX) are positive and significant at the 1% level. The coefficient on the market index (S&P 500 index average daily return) also remains negative and significant at the 1% level. For the other firm-specific variables: the coefficient of the leverage ratio is positive and significant at the 1% level; while the coefficient of the return on equity ratio is negative and significant at the 1% level; and the coefficient on the payout ratio is not significant. These regression coefficients, while not the focus of this chapter, are consistent with previous findings. Further, adding these variables increases the explanatory power of the regression (R^2 increases to 61%), suggesting that these variables provide explanatory power over and above the rating information.

The third regression in Table 5-3 incorporates all the variables in regression two and includes the first measure of short-selling (short-interest). The result is consistent with the univariate regression in Table 5-2. After controlling for the determinants of CDS spreads, the magnitude of the coefficient has fallen from 12.33 to 3.68. However, the coefficient remains positive and significant at the 1% level, suggesting a positive relationship between CDS spreads and short interest. In terms of economic significance, this implies that a 1% increase in the short-interest ratio will lead to a

3.68% increase in CDS spreads (given CDS spreads are measured in bps, this is equal to 3.68 bps).

The fourth regression in Table 5-3 replaces short-interest with a measure of the amount of stock available for lending, institutional ownership. After controlling for the determinants of CDS spreads, the institutional ownership coefficient is no longer significant (*t*-stat of 0.2). This result is inconsistent with the univariate regression in Table 5-2 and suggests that the explanatory power of institutional ownership is subsumed by other explanatory variables. The fifth regression in Table 5-3 replaces institutional ownership with utilisation. The result is consistent with the univariate regression in Table 5-2. After controlling for the determinants of CDS spreads, the magnitude of the coefficient has fallen from 2.52 to 0.57. However, the coefficient remains positive and significant at the 1% level, suggesting a positive relationship between CDS spreads and utilisation.

Given the coefficient on short-interest is positive and significant, while the coefficient on institutional ownership is insignificant, this suggests that the positive relationship between CDS spreads and utilisation is driven by an increase in short-interest. Overall the results in Table 5-3 suggest that CDS spreads are positively related to the level of short-selling (as measured by short-interest and utilisation), after controlling for the amount of stock available for short-selling (institutional ownership). This is consistent with main hypothesis ($H_{5,1}$) of this chapter.

Table 5-2 Determinants of CDS spreads: Univariate regressions

The univariate regressions use weekly data to explain the determinants of five-year CDS spreads for 330 entities with senior unsecured obligations with a modified restructuring clause from 1 July, 2006 to 1 September, 2008. The OLS regressions specification is

$$CDS_{i,t} = \alpha + \beta_e \, ExplantoryVariable_{i,,t-1} + \varepsilon_{i,t.}$$

Explanatory variables include lagged firm-specific and macro-financial variables including: recovery rates reported by Markit; firm-level equity return historical volatility; firms' balance sheet information, including the leverage ratio, return on equity, and dividend payout ratio; macro-financial variables including the market return (S&P 500 return) and volatility (VIX), short rate (three-month Treasury rate) and slope (10-year Treasury rate minus three-Month Treasury rate); and measures relating to short-selling including the amount of stock that is lent out for short-selling as a percentage of the total amount available for stock lending (Utilisation), the total number of shares held by all beneficial owners divided by the total number of shares outstanding (Institutional ownership) and the total number of shares lent, divided by the number of shares outstanding (Short Interest). Reported *t*-statistics are based on clustered standard errors that adjust for both time and firm effects (see Thompson, 2009).

	Dependant variable: Five-year CDS spread (bps)											
Explanatory variables	Recovery	Historical volatility	Return on equity	Dividend payout ratio	Leverage	Spot rate	Slope	VIX	Market return	Short-interest	Institutional ownership	Utilisation
Intercept	-347.13	-84.20	81.77	77.57	-2.19	172.39	55.17	-2.67	81.12	35.45	23.38	45.73
t-stat	*-2.83*	*-6.04*	*18.59*	*16.67*	*-0.26*	*14.44*	*16.67*	*-0.67*	*16.59*	*8.78*	*1.43*	*10.60*
Coefficient	10.66	95.51	-3.14	-0.44	3.58	-25.31	34.17	4.40	-81.89	12.33	2.47	2.52
t-stat	*3.47*	*9.94*	*-4.14*	*-0.34*	*7.55*	*-11.81*	*11.76*	*11.73*	*-7.59*	*8.79*	*3.26*	*5.82*
Adjusted R^2	0.03	0.32	0.06	0.01	0.27	0.11	0.10	0.06	0.01	0.28	0.03	0.16

Table 5-3 Determinants of CDS spreads: Multivariate regressions

The multivariate regressions use weekly data to explain the determinants of five-year CDS spreads for 330 entities with senior unsecured obligations with a modified restructuring clause from 1 July, 2006 to 1 September, 2008. The OLS regressions specification is

$$CDS_{i,t} = \alpha + \beta_s Short\text{-}selling_{i,,t-1} + \beta_v\ Volatility_{i,,t-1} + \beta_r\ Rating_{i,,t-1} + \beta_m\ Macro_{i,,t-1} + \beta_f\ Firm_{i,,t-1} + \beta_r\ Recovery_{i,,t-1} + \varepsilon_{i,t}$$

Explanatory variables include lagged firm-specific and macro-financial variables including: credit rating dummy variables; recovery rates reported by Markit; firm-level equity return historical volatility; firms' balance sheet information, including the leverage ratio, return on equity, and dividend payout ratio; macro-financial variables including the market return (S&P 500 return) and volatility (VIX), short rate (three-month Treasury rate) and slope (10-year Treasury rate minus three-month Treasury rate); and measures relating to short-selling including the amount of stock that is lent out for short-selling as a percentage of the total amount available for stock lending (Utilisation), the total number of shares held by all beneficial owners divided by the total number of shares outstanding (Institutional ownership) and the total number of shares lent, divided by the number of shares outstanding (Short Interest). Reported *t*-statistics are based on clustered standard errors that adjust for both time and firm effects (see Thompson 2009).

	1		2		3		4		5	
	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat
Intercept	18.03	*2.82*	-35.13	*-0.39*	-17.71	*-0.20*	-36.54	*-0.40*	-26.84	*-0.30*
AA	1.24	*0.19*	4.39	*0.35*	2.92	*0.27*	4.26	*0.34*	3.21	*0.28*
A	17.25	*2.63*	-13.25	*-1.00*	-14.83	*-1.31*	-13.70	*-1.04*	-14.87	*-1.23*
BBB	47.16	*6.70*	-1.88	*-0.13*	-5.01	*-0.41*	-2.44	*-0.17*	-5.37	*-0.41*
BB	193.51	*10.34*	85.92	*4.80*	73.57	*4.36*	85.24	*4.76*	79.09	*4.63*
B	320.48	*6.58*	194.49	*4.49*	174.71	*4.26*	193.79	*4.58*	185.29	*4.39*
Recovery			-0.53	*-0.23*	-0.48	*-0.21*	-0.54	*-0.23*	-0.59	*-0.25*
Spot Rate			-5.08	*-1.85*	-6.94	*-2.93*	-4.97	*-1.75*	-5.76	*-2.21*
Slope			3.21	*1.20*	1.47	*0.62*	3.27	*1.19*	2.82	*1.09*
VIX			0.71	*4.54*	0.49	*2.94*	0.69	*3.82*	0.68	*4.34*
Historical volatility			52.48	*6.33*	45.27	*5.50*	52.31	*6.07*	50.44	*6.12*
Market return			-24.52	*-3.43*	-22.36	*-3.52*	-24.75	*-3.38*	-24.29	*-3.48*
Leverage			1.90	*5.73*	1.70	*5.43*	1.90	*5.75*	1.75	*5.39*
Return on equity			-1.17	*-2.49*	-0.92	*-1.84*	-1.18	*-2.49*	-1.07	*-2.19*
Dividend payout ratio			-0.49	*-0.56*	-0.57	*-0.69*	-0.47	*-0.53*	-0.64	*-0.79*
Short-interest					3.68	*3.21*				
Institutional ownership							0.09	*0.20*		
Utilisation									0.57	*2.59*
Adjusted R^2	0.39		0.61		0.64		0.62		0.63	

5.4.4 Changes in CDS spreads

The results so far examine CDS spread levels, rather than changes in CDS spreads. Previous studies (see *inter alia* Greatrex, 2009; Zhang, Zhou and Zhu, 2009; and Ericsson, Jacobs and Oviedo, 2009) examine both levels and changes in CDS spreads. Greatrex (2009) finds that spread levels tend to be non-stationary, while spread changes are stationary. Thus any findings using levels (as opposed to changes) are potentially subject to spurious regression inferences. Therefore the following regression is also estimated:

$$\Delta CDS_{i,t} = \alpha + \beta_s\, \Delta Short\text{-}selling_{i,,t} + \beta_v \Delta Volatility_{i,,t} + \beta_m \Delta Macro_{i,,t} + \beta_f\, \Delta Firm_{i,,t} + \varepsilon_{i,t} \tag{5.5}$$

This regression examines the relation of weekly changes in CDS spreads with contemporaneous changes in explanatory variables. The regression includes all explanatory variables except rating information and recovery rates as these variables rarely display any variation. Overall, the results in Table 5-4 show the explanatory power of the model is much lower when examining spread changes compared to spread levels. This is consistent with previous studies on both credit spread changes (see *inter alia* Collin-Dufresne, Goldstein and Martin, 2001) and CDS spread changes (see *inter alia* Zhang, Zhou and Zhu, 2009; and Ericsson, Jacobs and Oviedo, 2009).

Importantly, the short-interest coefficient remains positive and statistically significant when regressed against CDS spread changes in both the univariate and multivariate regressions. The institutional ownership coefficient remains positive and significant when regressed against CDS spread changes in the univariate regressions and insignificant in the multivariate regressions. The utilisation coefficient also remains consistent with the level regressions in Table 5-3. Overall, the results in Table 5-4 remain consistent with the main hypothesis ($H_{5,1}$) and suggest that short-selling is not only positively related to CDS spread levels, but also changes in CDS spreads.

5.4.5 Additional tests

The results in the previous sections suggest a positive relationship between short-selling and CDS spreads. In this section, the robustness of these results is probed by examining various regression specifications and techniques. First in Table 5-5, following previous studies (i.e., Benkert, 2004), fixed effects are included for time and firm. Second in Table 5-6, following Zhang, Zhou and Zhu (2009), regressions are conducted excluding ratings dummies and dividing the sample into the three rating groups used in Table 5-1: AAA to A; BBB; and BBB and below. Third in Table 5-7 and Table 5-8, following Collin-Dufresne, Goldstein and Martin (2001) and Ericsson, Jacobs and Oviedo (2009), average regression coefficients are calculated using a series of time-series regressions, one for each entity. These regressions, similar to including firm fixed effects, control for variation among firms. Fourth in Table 5-9, following Ericsson, Jacobs and Oviedo (2009), CDS spread levels are regressed against contemporaneous explanatory variables. Fifth, it is possible that the results are being driven by a particular industry sector; therefore in Table 5-10 regressions are conducted by industry sectors. Finally, it is possible that the results are being driven by a particular part of the sample period. Figure 5-1 shows that CDS spreads increase from July 2007, which coincides with the collapse of the Bears Stearns subprime mortgage hedge funds. Therefore, in Table 5-11 regressions are conducted by dividing the sample period into pre- and post-July 2007.

The most notable changes between techniques include: incorporating fixed effects leads to increased explanatory power (R^2 increases to 84%); conducting regressions by industry sector leads to significant and positive coefficients on short-interest and utilisation in five of seven sectors (consumer goods, healthcare, industrials, oil and gas, and technology) and insignificant coefficients in the remaining two sectors (basic materials and telecommunications); and using contemporaneous explanatory variables increases the magnitude and significance of the relationship between short-selling and CDS spreads. Overall, the coefficient direction and significance of the explanatory variables, in particular short-interest and utilisation, remain qualitatively unchanged. This demonstrates the results are robust to different specifications and regression techniques.

Table 5-4 Determinants of CDS spread changes

The regressions examine the determinants of weekly changes in five-year CDS spreads for 330 entities with senior unsecured obligations with a modified restructuring clause from 1 July, 2006 to 1 September, 2008. The OLS regressions specification is

$$\Delta CDS_{i,t} = \alpha + \beta_s\ \Delta Short\text{-}selling_{i,,t} + \beta_v \Delta Volatility_{i,,t} + \beta_m \Delta Macro_{i,,t} + \beta_f\ \Delta Firm_{i,,t} + \varepsilon_{i,t}$$

Explanatory variables include contemporaneous weekly changes in firm-specific and macro-financial variables including: measures relating to short-selling including the amount of stock that is lent out for short-selling as a percentage of the total amount available for stock lending (Utilisation), the total number of shares held by all beneficial owners divided by the total number of shares outstanding (Institutional ownership) and the total number of shares lent, divided by the number of shares outstanding (Short Interest); firm-level equity return historical volatility; firms' balance sheet information, including the leverage ratio, return on equity, and dividend payout ratio; and macro-financial variables including the market return (S&P 500 return) and volatility (VIX), short rate (three-month Treasury rate) and slope (10-year Treasury rate minus three-month Treasury rate). Δ represents the first difference in variables. Reported *t*-statistics are based on clustered standard errors that adjust for both time and firm effects (see Thompson 2009).

	1		2		3		4		5		6		7	
	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat
Intercept	0.01	*29.06*	0.01	*28.86*	0.01	*29.00*	0.02	*31.17*	0.02	*31.42*	0.02	*31.13*	0.02	*31.30*
Δ Short-interest	0.01	*1.98*							0.01	*1.96*				
Δ Institutional ownership			0.02	*2.36*							0.01	*0.36*		
Δ Utilisation					0.01	*1.92*							0.01	*1.81*
Δ Spot Rate							-0.01	*-0.84*	-0.01	*-0.66*	-0.01	*-0.63*	-0.01	*-0.64*
Δ Slope							0.01	*11.02*	0.01	*11.01*	0.01	*10.98*	0.01	*11.01*
Δ VIX							0.12	*17.32*	0.12	*17.29*	0.12	*17.23*	0.12	*17.32*
Δ Historical volatility							0.05	*1.52*	0.04	*1.44*	0.04	*1.45*	0.04	*1.44*
Market return							-0.16	*-24.79*	-0.16	*-24.88*	-0.16	*-24.91*	-0.16	*-24.90*
Δ Leverage							0.08	*3.51*	0.08	*3.50*	0.08	*3.49*	0.08	*3.49*
Δ Return on equity							-0.01	*-1.68*	-0.01	*-1.67*	-0.01	*-1.68*	-0.01	*-1.68*
Δ Dividend payout ratio							0.15	*5.59*	0.15	*5.59*	0.15	*5.58*	0.15	*5.59*
Adjusted R^2	0.01		0.01		0.01		0.09		0.10		0.10		0.10	

Table 5-5 Determinants of CDS spreads: Multivariate regressions using firm fixed effects

The multivariate regressions use weekly data to explain the determinants of five-year CDS spreads for 330 entities with senior unsecured obligations with a modified restructuring clause from 1 July, 2006 to 1 September, 2008. The OLS regressions specification is

$$CDS_{i,t} = \alpha + \beta_s Short\text{-}selling_{i,,t-1} + \beta_v\ Volatility_{i,,t-1} + \beta_r\ Rating_{i,,t-1} + \beta_m\ Macro_{i,,t-1} + \beta_f\ Firm_{i,,t-1} + \beta_r\ Recovery_{i,,t-1} + \varepsilon_{i,t}$$

Explanatory variables include lagged firm-specific and macro-financial variables including: credit rating dummy variables; recovery rates reported by Markit; firm-level equity return historical volatility; firms' balance sheet information, including the leverage ratio, return on equity, and dividend payout ratio; macro-financial variables including the market return (S&P 500 return) and volatility (VIX), short rate (three-month Treasury rate) and slope (10-year Treasury rate minus three-month Treasury rate); and measures relating to short-selling including the amount of stock that is lent out for short-selling as a percentage of the total amount available for stock lending (Utilisation), the total number of shares held by all beneficial owners divided by the total number of shares outstanding (Institutional ownership) and the total number of shares lent, divided by the number of shares outstanding (Short Interest). Fixed effects for each firm are included. *t*-statistics are based on clustered standard errors that adjust for both time and firm effects (see Thompson 2009).

	1		2		3		4		5	
	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat
Intercept	-20.59	*-0.79*	23.50	*1.01*	38.36	*1.67*	12.14	*0.52*	26.90	*1.16*
AA	26.91	*2.03*	-17.33	*-1.73*	-14.10	*-1.43*	-17.04	*-1.70*	0.47	*13.64*
A	13.16	*0.58*	-0.11	*-0.01*	-2.74	*-0.16*	-0.05	*0.00*	-3.71	*-13.33*
BBB	68.70	*2.92*	22.08	*1.24*	19.25	*1.10*	22.04	*1.24*	0.50	*0.42*
BB	429.42	*17.78*	242.93	*13.30*	236.98	*13.13*	242.49	*13.28*	6.10	*3.74*
B	626.60	*25.02*	398.83	*21.03*	387.00	*20.66*	397.70	*20.98*	0.73	*8.87*
Recovery			-3.66	*-13.11*	-3.64	*-13.20*	-3.63	*-13.00*	57.77	*53.58*
Spot Rate			0.86	*0.71*	-0.01	*-0.01*	1.69	*1.39*	-29.38	*-7.57*
Slope			6.38	*3.90*	4.97	*3.07*	6.81	*4.16*	3.85	*53.95*
VIX			0.75	*9.07*	0.59	*7.25*	0.70	*8.33*	0.19	*4.62*
Historical volatility			58.28	*53.90*	55.47	*51.70*	58.58	*54.13*	-0.11	*-0.60*
Market return			-29.80	*-7.65*	-28.37	*-7.37*	-31.11	*-7.97*	-16.33	*-1.64*
Leverage			4.08	*58.75*	3.63	*51.24*	4.09	*58.79*	-1.61	*-0.10*
Return on equity			0.19	*4.52*	0.25	*6.10*	0.20	*4.82*	23.25	*1.31*
Dividend payout ratio			-0.08	*-0.47*	-0.25	*-1.39*	-0.08	*-0.45*	244.69	*13.44*
Short-interest					3.23	*26.44*				
Institutional ownership							0.38	*5.05*		
Utilisation									399.48	*21.14*
Adjusted R^2	0.69		0.82		0.83		0.83		0.83	

Table 5-6 Determinants of CDS spreads: Multivariate regressions by rating groups

The multivariate regressions use weekly data to explain the determinants of five-year CDS spreads for 330 entities with senior unsecured obligations with a modified restructuring clause from 1 July, 2006 to 1 September, 2008. The regressions are conducted dividing the sample into the three rating groups: AAA to A; BBB; and BBB and below. The OLS regressions specification is

$$CDS_{i,t} = \alpha + \beta_s Short\text{-}selling_{i,t-1} + \beta_v\, Volatility_{i,,t-1} + \beta_m\, Macro_{i,,t-1} + \beta_f\, Firm_{i,,t-1} + \beta_r\, Recovery_{i,,t-1} + \varepsilon_{i,t}$$

Explanatory variables include lagged firm-specific and macro-financial variables including: recovery rates reported by Markit; firm-level equity return historical volatility; firms' balance sheet information, including the leverage ratio, return on equity, and dividend payout ratio; macro-financial variables including the market return (S&P 500 return) and volatility (VIX), short rate (three-month Treasury rate) and slope (10-year Treasury rate minus three-month Treasury rate); and measures relating to short-selling including the amount of stock that is lent out for short-selling as a percentage of the total amount available for stock lending (Utilisation), the total number of shares held by all beneficial owners divided by the total number of shares outstanding (Institutional ownership) and the total number of shares lent, divided by the number of shares outstanding (Short Interest). *t*-statistics are based on clustered standard errors that adjust for both time and firm effects (see Thompson 2009).

Rating category	AAA to A							
	1		2		3		4	
	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat
Intercept	30.61	*0.77*	30.03	*0.78*	24.44	*0.61*	22.34	*0.56*
Recovery	0.01	*0.01*	0.13	*0.14*	-0.07	*-0.08*	0.27	*0.29*
Spot Rate	-7.67	*-6.51*	-8.14	*-7.05*	-7.18	*-5.80*	-7.98	*-6.67*
Slope	1.22	*1.28*	0.84	*0.84*	1.44	*1.46*	1.24	*1.19*
VIX	0.14	*2.52*	0.07	*1.39*	0.06	*0.87*	0.13	*2.18*
Historical volatility	15.70	*4.63*	12.85	*4.86*	15.08	*4.42*	13.43	*4.93*
Market return	-14.36	*-4.81*	-14.26	*-4.84*	-15.86	*-5.30*	-15.18	*-5.15*
Leverage	0.49	*4.38*	0.44	*4.45*	0.49	*4.42*	0.42	*4.27*
Return on equity	-0.82	*-0.75*	-0.71	*-0.75*	-0.84	*-0.78*	-0.77	*-0.77*
Dividend payout ratio	-2.18	*-0.63*	-2.96	*-0.91*	-1.43	*-0.41*	-2.72	*-0.82*
Short-interest			2.28	*2.94*				
Institutional ownership					0.46	*1.71*		
Utilisation							0.53	*2.48*
Adjusted R^2	0.48		0.52		0.49		0.51	

Table 5-6 – Continued

Rating category	BBB							
	1		2		3		4	
	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat
Intercept	-196.65	*-2.77*	-182.84	*-2.62*	-199.88	*-2.82*	-191.35	*-2.72*
Recovery	4.58	*2.72*	4.37	*2.65*	4.59	*2.73*	4.47	*2.68*
Spot Rate	-8.48	*-3.49*	-9.04	*-3.72*	-8.32	*-3.44*	-8.64	*-3.57*
Slope	-0.26	*-0.13*	-0.76	*-0.38*	-0.17	*-0.09*	-0.33	*-0.16*
VIX	0.29	*1.93*	0.22	*1.41*	0.26	*1.57*	0.28	*1.86*
Historical volatility	43.69	*6.21*	41.51	*5.49*	43.32	*6.02*	43.37	*6.09*
Market return	-8.48	*-1.36*	-8.45	*-1.37*	-8.85	*-1.42*	-8.28	*-1.34*
Leverage	1.58	*5.79*	1.52	*5.36*	1.59	*5.82*	1.54	*5.41*
Return on equity	-1.21	*-2.91*	-1.17	*-2.88*	-1.21	*-2.89*	-1.20	*-2.91*
Dividend payout ratio	0.84	*1.10*	0.87	*1.14*	0.94	*1.27*	0.76	*0.98*
Short-interest			1.00	*1.64*				
Institutional ownership					0.13	*0.53*		
Utilisation							0.10	*0.78*
Adjusted R^2	0.45		0.47		0.46		0.46	

Table 5-6 – Continued

Rating category	BBB and below							
	1		2		3		4	
	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat
Intercept	-52.60	*-0.30*	-27.07	*-0.17*	-35.88	*-0.19*	-47.68	*-0.29*
Recovery	-0.27	*-0.08*	-0.12	*-0.04*	-0.23	*-0.07*	-0.25	*-0.08*
Spot Rate	-12.58	*-0.81*	-18.28	*-1.34*	-13.64	*-0.85*	-15.76	*-1.09*
Slope	12.04	*0.69*	4.55	*0.28*	11.64	*0.66*	7.67	*0.45*
VIX	3.06	*3.67*	2.45	*2.76*	3.13	*3.74*	3.00	*3.56*
Historical volatility	62.99	*2.45*	51.71	*2.06*	63.03	*2.44*	56.25	*2.20*
Market return	-70.90	*-1.77*	-48.83	*-1.35*	-72.13	*-1.81*	-71.75	*-1.81*
Leverage	3.81	*4.07*	3.29	*3.57*	3.83	*4.02*	3.39	*3.80*
Return on equity	-0.37	*-0.49*	0.12	*0.16*	-0.35	*-0.47*	0.04	*0.05*
Dividend payout ratio	-1.34	*-1.73*	-1.47	*-2.15*	-1.28	*-1.66*	-1.15	*-1.54*
Short-interest			6.21	*2.96*				
Institutional ownership					-0.68	*-0.43*		
Utilisation							1.59	*2.36*
Adjusted R^2	0.46		0.51		0.46		0.49	

Table 5-7 Determinants of CDS spreads: Multivariate regressions (average coefficients)

The average regression coefficients are estimated using a series of time-series regressions, one for each entity. For each entity weekly data is used to explain the determinants of five-year CDS spreads for 330 entities with senior unsecured obligations with a modified restructuring clause from 1 July, 2006 to 1 September, 2008. The OLS regressions specification is

$$CDS_{i,t} = \alpha + \beta_s Short\text{-}selling_{i,t} + \beta_v\, Volatility_{i,,t} + \beta_m\, Macro_{i,,t} + \beta_f\, Firm_{i,,t} + \varepsilon_{i,t}$$

Explanatory variables include contemporaneous firm-specific and macro-financial variables including: recovery rates reported by Markit; firm-level equity return historical volatility; firms' balance sheet information, including the leverage ratio, return on equity, and dividend payout ratio; macro-financial variables including the market return (S&P 500 return) and volatility (VIX), short rate (three-month Treasury rate) and slope (10-year Treasury rate minus three-month Treasury rate); and measures relating to short-selling including the amount of stock that is lent out for short-selling as a percentage of the total amount available for stock lending (Utilisation), the total number of shares held by all beneficial owners divided by the total number of shares outstanding (Institutional ownership) and the total number of shares lent, divided by the number of shares outstanding (Short Interest). *t*-statistics are calculated using the time-series regression coefficients as in Collin-Dufresne, Goldstein and Martin (2001).

	1		2		3	
	Avg. coefficient	*t*-stat	Avg. coefficient	*t*-stat	Avg. coefficient	*t*-stat
Intercept	64.58	*0.87*	79.96	*0.97*	78.64	*1.07*
Spot Rate	-20.87	*-5.89*	-19.90	*-4.54*	-24.56	*-3.05*
Term spread	-6.74	*-2.38*	-6.96	*-1.96*	-11.34	*-1.45*
VIX	0.77	*3.52*	1.08	*2.50*	0.96	*2.22*
Historical volatility	8.33	*1.66*	13.02	*2.21*	8.00	*0.78*
Market return	-9.92	*-1.61*	-8.81	*-1.48*	-10.06	*-1.58*
Leverage	14.22	*0.80*	79.30	*1.20*	21.67	*1.20*
Return on equity	-4.75	*-0.33*	6.30	*0.32*	-4.58	*-0.32*
Dividend payout ratio	1115.74	*1.05*	928.17	*0.83*	846.98	*1.05*
Short-interest	4.08	*1.27*				
Institutional ownership			-0.16	*-0.16*		
Utilisation					-0.38	*-0.62*
Adjusted R^2	0.82		0.81		0.81	

Table 5-8 Determinants of CDS spreads: Univariate regressions using contemporaneous variables

The univariate regressions use weekly data to explain the determinants of five-year CDS spreads for 330 entities with senior unsecured obligations with a modified restructuring clause from 1 July, 2006 to 1 September, 2008. The OLS regressions specification is

$$CDS_{i,t} = \alpha + \beta_e\ ExplantoryVariable_{i,,t} + \varepsilon_{i,t.}$$

Explanatory variables include contemporaneous firm-specific and macro-financial variables including: recovery rates reported by Markit; firm-level equity return historical volatility; firms' balance sheet information, including the leverage ratio, return on equity, and dividend payout ratio; macro-financial variables including the market return (S&P 500 return) and volatility (VIX), short rate (three-month Treasury rate) and slope (10-year Treasury rate minus three-month Treasury rate); and measures relating to short-selling including the amount of stock that is lent out for short-selling as a percentage of the total amount available for stock lending (Utilisation), the total number of shares held by all beneficial owners divided by the total number of shares outstanding (Institutional ownership) and the total number of shares lent, divided by the number of shares outstanding (Short Interest). *t*-statistics are based on clustered standard errors that adjust for both time and firm effects (see Thompson 2009).

	Dependant variable: Five-year CDS spread (bps)											
Explanatory variables	Recovery	Historical volatility	Return on equity	Dividend payout ratio	Leverage	Spot rate	Slope	VIX	Market return	Short-interest	Institutional ownership	Utilisation
Intercept	-334.31	-84.71	81.50	77.43	-2.32	172.10	54.36	-3.43	80.70	35.32	23.19	45.36
t-stat	-2.63	-6.11	18.57	16.72	-0.28	14.51	16.63	-0.86	16.61	8.92	1.44	10.74
Coefficient	10.33	95.31	-3.09	-0.42	3.58	-25.42	34.36	4.43	-75.83	12.08	2.43	2.47
t-stat	3.25	10.03	-4.07	-0.33	7.62	-11.89	11.83	11.83	-6.85	8.80	3.25	5.84
Adjusted R^2	0.03	0.33	0.06	0.00	0.27	0.11	0.10	0.06	0.01	0.28	0.03	0.16

Table 5-9 Determinants of CDS spreads: Multivariate regressions using contemporaneous variables

The multivariate regressions use weekly data to explain the determinants of five-year CDS spreads for 330 entities with senior unsecured obligations with a modified restructuring clause from 1 July, 2006 to 1 September, 2008. The OLS regressions specification is

$$CDS_{i,t} = \alpha + \beta_s Short\text{-}selling_{i\,i,,t} + \beta_v\, Volatility_{i,,t} + \beta_r\, Rating_{i,,t} + \beta_m\, Macro_{i,,t} + \beta_f\, Firm_{i,,t} + \beta_r\, Recovery_{i,,t} + \varepsilon_{i,t}$$

Explanatory variables include contemporaneous firm-specific and macro-financial variables including: credit rating dummy variables; recovery rates reported by Markit; firm-level equity return historical volatility; firms' balance sheet information, including the leverage ratio, return on equity, and dividend payout ratio; macro-financial variables including the market return (S&P 500 return) and volatility (VIX), short rate (three-month Treasury rate) and slope (10-year Treasury rate minus three-month Treasury rate); and measures relating to short-selling including the amount of stock that is lent out for short-selling as a percentage of the total amount available for stock lending (Utilisation), the total number of shares held by all beneficial owners divided by the total number of shares outstanding (Institutional ownership) and the total number of shares lent, divided by the number of shares outstanding (Short Interest). *t*-statistics are based on clustered standard errors that adjust for both time and firm effects (see Thompson 2009).

	1		2		3		4		5	
	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat
Intercept	17.93	*2.84*	-26.72	*-0.28*	-15.42	*-0.18*	-32.95	*-0.37*	-24.08	*-0.28*
AA	1.22	*0.19*	4.30	*0.34*	2.98	*0.28*	4.30	*0.35*	3.26	*0.29*
A	17.24	*2.66*	-13.56	*-1.02*	-14.45	*-1.29*	-13.24	*-1.01*	-14.50	*-1.21*
BBB	47.28	*6.78*	-2.21	*-0.16*	-4.54	*-0.38*	-1.92	*-0.14*	-4.90	*-0.38*
BB	192.49	*10.42*	84.37	*4.71*	73.30	*4.39*	84.62	*4.78*	78.53	*4.64*
B	319.14	*6.72*	192.47	*4.55*	174.75	*4.37*	193.13	*4.67*	184.78	*4.49*
Recovery			-0.68	*-0.28*	-0.43	*-0.19*	-0.49	*-0.22*	-0.53	*-0.24*
Spot Rate			-6.53	*-2.36*	-8.72	*-3.67*	-6.88	*-2.44*	-7.60	*-2.92*
Slope			0.67	*0.25*	-1.54	*-0.69*	0.16	*0.06*	-0.25	*-0.10*
VIX			0.87	*5.35*	0.70	*4.16*	0.89	*4.93*	0.88	*5.52*
Historical volatility			52.93	*6.39*	45.18	*5.54*	51.94	*6.09*	50.10	*6.12*
Market return			-11.36	*-1.49*	-6.54	*-1.01*	-8.75	*-1.18*	-8.38	*-1.19*
Leverage			1.89	*5.74*	1.67	*5.49*	1.86	*5.79*	1.71	*5.45*
Return on equity			-1.13	*-2.39*	-0.86	*-1.77*	-1.10	*-2.42*	-1.00	*-2.13*
Dividend payout ratio			-0.44	*-0.49*	-0.55	*-0.68*	-0.46	*-0.53*	-0.62	*-0.78*
Short-interest					3.50	*3.14*				
Institutional ownership							0.06	*0.14*		
Utilisation									0.54	*2.57*
Adjusted R^2	0.39		0.61		0.64		0.62		0.63	

Table 5-10 Determinants of CDS spreads: Multivariate Short-interest regressions by industry Sector

The multivariate regressions use weekly data to explain the determinants of five-year CDS spreads for 330 entities with senior unsecured obligations with a modified restructuring clause from 1 July, 2006 to 1 September, 2008. The regressions are conducted dividing the sample by industry sector. The OLS regressions specification

$$CDS_{i,t} = \alpha + \beta_s Short\text{-}interest_{,,t-1} + \beta_v\, Volatility_{i,,t-1} + \beta_m\, Macro_{i,,t-1} + \beta_f\, Firm_{i,,t-1} + \beta_r\, Recovery_{i,,t-1} + \varepsilon_{i,t}$$

Explanatory variables include lagged firm-specific and macro-financial variables including: recovery rates reported by Markit; firm-level equity return historical volatility; firms' balance sheet information, including the leverage ratio, return on equity, and dividend payout ratio; macro-financial variables including the market return (S&P 500 return) and volatility (VIX), short rate (three-month Treasury rate) and slope (10-year Treasury rate minus three-month Treasury rate); and the total number of shares lent, divided by the number of shares outstanding (Short Interest). *t*-statistics are based on clustered standard errors that adjust for both time and firm effects (see Thompson 2009).

	Basic materials		Consumer goods		Healthcare		Industrials	
	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat
Intercept	-196.97	*-3.92*	-191.80	*-1.23*	287.62	*2.10*	-162.79	*-1.59*
Recovery	5.16	*8.22*	1.56	*0.41*	-7.31	*-2.21*	0.26	*0.11*
Spot Rate	-5.09	*-0.86*	3.16	*0.59*	-10.67	*-2.06*	3.41	*0.58*
Slope	-1.61	*-0.32*	9.58	*1.75*	-8.23	*-1.30*	2.58	*0.48*
VIX	0.18	*0.61*	0.68	*1.83*	0.50	*1.04*	0.71	*1.80*
Historical volatility	27.51	*2.12*	62.23	*4.94*	14.65	*1.68*	93.52	*3.25*
Market return	-3.25	*-0.28*	-51.16	*-3.26*	-21.03	*-1.61*	14.48	*1.28*
Leverage	1.43	*2.32*	2.57	*2.76*	4.31	*5.88*	1.53	*4.14*
Return on equity	-1.46	*-1.14*	-0.18	*-0.27*	4.39	*1.29*	-3.20	*-3.22*
Dividend payout ratio	0.31	*0.02*	0.93	*0.06*	-1.37	*-4.05*	2.12	*1.58*
Short-interest	-1.04	*-0.74*	6.41	*4.10*	2.09	*1.92*	3.57	*1.66*
No. Obs.	29		111		26		74	
Adjusted R^2	0.29		0.57		0.77		0.59	

Table 5-10 – Continued

	Oil and gas		Technology		Telecom	
	Coef.	*t*-stat	Coef.	*t*-stat	Coef.	*t*-stat
Intercept	-309.37	*-4.03*	97.56	*0.40*	-806.95	*-2.73*
Recovery	7.56	*3.92*	-2.61	*-0.41*	10.81	*1.72*
Spot Rate	-7.65	*-3.10*	-2.99	*-0.40*	18.96	*1.60*
Slope	3.56	*1.30*	3.72	*0.55*	3.27	*0.28*
VIX	0.41	*1.67*	0.63	*1.47*	1.60	*2.20*
Historical volatility	29.29	*2.79*	35.45	*2.91*	116.69	*6.37*
Market return	-12.27	*-1.54*	-31.44	*-1.10*	-102.15	*-3.44*
Leverage	1.40	*4.35*	2.23	*2.77*	5.79	*2.61*
Return on equity	-1.28	*-0.82*	-19.29	*-3.99*	0.12	*0.93*
Dividend payout ratio	-1.19	*-0.24*	-15.18	*-0.41*	21.11	*1.49*
Short-interest	2.06	*1.74*	4.76	*2.07*	-1.11	*-0.53*
No. Obs.	51		20		19	
Adjusted R^2	0.50		0.50		0.76	

Table 5-11 Determinants of CDS spreads: Multivariate short-interest regressions by sample period

The multivariate regressions use weekly data to explain the determinants of five-year CDS spreads for 330 entities with senior unsecured obligations with a modified restructuring clause from 1 July, 2006 to *1 September*, 2008. The regressions are conducted dividing the sample into the periods pre and post July 2007. The OLS regressions specification

$$CDS_{i,t} = \alpha + \beta_s Short\text{-}interest_{,,t-1} + \beta_v\ Volatility_{i,,t-1} + \ \beta_m\ Macro_{i,,t-1} + \beta_f\ Firm_{i,,t-1} + \beta_r\ Recovery_{i,,t-1} + \varepsilon_{i,t}$$

Explanatory variables include lagged firm-specific and macro-financial variables including: recovery rates reported by Markit; firm-level equity return historical volatility; firms' balance sheet information, including the leverage ratio, return on equity, and dividend payout ratio; macro-financial variables including the market return (S&P 500 return) and volatility (VIX), short rate (three-month Treasury rate) and slope (10-year Treasury rate minus three-month Treasury rate); and the total number of shares lent, divided by the number of shares outstanding (Short Interest). *t*-statistics are based on clustered standard errors that adjust for both time and firm effects (see Thompson 2009).

Sample period	1 July, 2006 - 31 June, 2007		1 July, 2007 - 1 September 2008	
	Coef.	*t*-stat	Coef.	*t*-stat
Intercept	-115.41	-2.81	11.30	0.1
AA	1.89	0.39	7.61	0.52
A	3.35	0.62	-19.41	-1.26
BBB	19.50	3.28	-9.46	-0.58
BB	75.92	7.19	89.03	3.78
B	168.06	7.46	190.67	3.61
Recovery	2.86	3.22	-1.70	-0.58
Spot Rate	-0.36	-0.08	-8.03	-2.72
Slope	8.64	3.48	-3.64	-0.72
VIX	-0.37	-1.86	0.69	5.84
Historical volatility	17.37	3.67	50.53	4.37
Market return	-54.95	-2.7	-17.06	-2.62
Leverage	0.56	3.41	2.33	5.27
Return on equity	-1.52	-1.05	-0.62	-1.19
Dividend payout ratio	0.08	0.38	-0.37	-0.25
Short-interest	1.51	2.41	3.88	2.81
Adjusted R^2	0.66		0.64	

5.5 Summary

In this chapter, the determinants of firm-level CDS spreads are examined, using a new measure of the likelihood of firm default - short-selling. By examining the relationship between CDS spreads and short-selling, this chapter adds to the existing literature which examines the determinants of CDS spreads and also adds to the existing literature on the information content of short-selling. This chapter firstly estimates the relationship between CDS spreads and the theoretical determinants of CDS spreads using OLS univariate regressions. The univariate results reveal that the variables which explain the greatest variation in CDS spreads are those predicted by the structural form models. The key coefficients of interest, short-interest and utilisation (measures of short-selling) are positive and significant when regressed against CDS spreads. While the univariate analysis shows that CDS spreads are positively related to short-selling, these regressions do not control for the theoretical determinants of CDS spreads.

After controlling for the determinants of CDS spreads (credit ratings, firm-specific variables and macro-financial variables), the coefficient on the measures of short-selling (short-interest and utilisation) remain positive and significant. These results are economically significant and robust to various controls including controlling for the supply of stock for short-selling, the use of changes in CDS spreads, cross-sectional controls for fixed effects, subgroup analysis by industry sector and credit rating categories, calculation of average regression coefficients using time-series regressions and the use of contemporaneous explanatory variables.

While results indicate that short-selling exhibits a positive relationship with CDS spreads, the question remains whether short-selling leads the CDS market or vice versa. Previous studies which examine the relationship between CDS spreads and stock markets (see *inter alia* Norden and Weber, 2009, and Forte and Pena, 2009) document that stock market returns lead CDS spread changes, suggesting price discovery occurs in the stock market more often than in the CDS market. Given short-selling occurs in the stock market, this implies that short-selling is likely to lead the CDS market. This is consistent with the notion that short-sellers are informed (see *inter alia* Boehmer, Jones and Zhang, 2008), given the majority of price discovery occurs in the stock market. Possible explanations for stock returns leading CDS spreads could be the structural difference between the markets in which the assets are traded. The structural differences could imply probable differences in the relative speed with which respective markets respond to the changes in credit conditions. For example, CDS markets for individual firms are OTC compared to stock markets which are traded through an electronic exchange.

Chapter 6: Conclusions

This dissertation analyses the impact of short-selling in financial markets. The importance of this subject is underscored by the increasing participation by short-sellers in equity markets. The increasing prevalence of short-selling has also been associated with the common belief that short-selling precedes market price declines and produces unfair speculative profits. This belief has sparked regulation to forbid short-selling during the recent financial crisis. Given the prevalence of short-selling and the potential harm to markets, it is critical for investors, regulators, and academics to further understand the impact of short-selling in financial markets. Hence, the main objective of this dissertation is to empirically examine the impact of short-selling in financial markets.

Chapter 3 empirically examines the impact of the 2008 short-selling bans on the market quality of stocks. While short-selling has long been a contentious issue (see Chancellor, 2001), relatively little or no empirical evidence is available on the impact of short-sale restrictions on market quality. The 2008 short-sale bans provide an ideal setting for these tests because it provides a binding constraint. Thus, there is no need to rely on proxies for short-sale constraints, as in previous research. Using data from 14 equity markets the market quality of financial stocks subject to the bans is examined by comparing them to stocks not subject to the bans. Evidence indicates that restrictions on short-selling lead to artificially inflated prices, indicated by positive abnormal returns. This is consistent with Miller's (1977) overvaluation theory and suggests that the bans have been effective in temporarily stabilising prices in struggling financial stocks.

Market quality is reduced during the restrictions, as evidenced by wider bid-ask spreads, increased price volatility and reduced trading activity. While these effects are strong, regulators may have seen the deterioration in market quality as a necessary by-product of the bans to maintain prices and protect investors. Regulators feared the possibility of manipulative short-selling in financial stocks and felt it was necessary to undertake extreme measures. Perhaps the regulatory intervention was designed to boost investor outlook and confidence to provide positive externalities through the economy. Overall, whether the net effect of the short-selling bans is positive (higher prices versus lower market quality) is open to debate.

Chapter 4 examines the impact of allowing *naked* short-selling on the securities lending and equity market in a unique market setting where naked short-sales are restricted to certain securities on an approved list. The existing literature on the impact of short-selling examines changes in the rules governing either covered short-sales, or changes to short-sale constraints that affect both naked and covered short-sales. This is interesting as, despite the apparent assumption that naked short-selling is detrimental, relatively little or no empirical evidence is available on the impact that naked short-selling has on financial markets. The purpose of the second chapter is to bridge this gap in the literature by directly examining the impact of allowing *naked* short-selling on returns, volatility and liquidity.

Consistent with Miller (1977), stocks with the highest dispersion of opinion and highest short-sale constraint (higher lending fees) are the only stocks to exhibit significant and negative abnormal returns in the post event period. These stocks experience a -3.4148% abnormal return on the event date, significant at the 1% level. The impact of allowing naked short-selling on volatility and liquidity is examined using both a matching and regression discontinuity design. The results, consistent across both methods, reveal a small increase in the daily and intraday volatility of individual stock returns. Further, allowing naked short-selling leads to small reduction in liquidity via increased transaction costs (wider bid-ask spreads and effective spreads). Further testing reveals that the impact of naked short-selling on market quality variables is greater, both in magnitude and significance, in stocks with higher short-sale constraints. Stocks with relatively low short-sale constraints experience smaller or no significant change from the introduction of naked short-sales. This is consistent with the notion that stocks with lower lending fees experience relatively little naked short-selling since covered short-selling is less expensive.

Using the Lin, Sanger and Booth (1995) spread decomposition model, the increase in bid-ask spread is attributed to an increase in the adverse selection component. This is consistent with the notion that short-sellers are likely to be informed traders. Analysis of the securities lending market reveals that the demand for securities lending is reduced following the introduction of naked short-selling. While the evidence is not conclusive, naked short-selling appears to occur once stocks are added to the designated list of eligible stocks. Therefore the results in this chapter can be attributed (at least in part) to the introduction of naked short-sales. Overall, the results are of interest to policy makers who have recently moved towards curbing naked short-selling. It appears that these moves may be warranted, with the evidence suggesting that allowing naked short-selling impairs liquidity and increases stock price volatility. However, there appears to be some improvement in price efficiency and the results are largely limited to stocks with high short-sale constraints.

Chapter 5 examines the determinants of firm-level CDS spreads, using a new measure of the likelihood of firm default - short-selling. By examining the relationship between CDS spreads and short-selling, this chapter adds to the existing literature which examines the determinants of CDS spreads and also adds to the existing literature on the information content of short-selling. This chapter first estimates the relationship between CDS spreads and the theoretical determinants of CDS spreads using OLS univariate regressions. The univariate results reveal that the variables which explain the greatest variation in CDS spreads are those predicted by the structural form models. The key coefficients of interest, short-interest and utilisation (measures of short-selling), are positive and significant when regressed against CDS spreads. While the univariate analysis shows that CDS spreads are positively related to short-selling, these regressions do not control for the theoretical determinants of CDS spreads.

After controlling for the determinants of CDS spreads (credit ratings, firm-specific variables and macro-financial variables), the coefficient on the measures of short-selling (short-interest and utilisation) remain positive and significant. These results are economically significant and robust to various controls including controlling for the supply of stock for short-selling, the use of changes in CDS spreads, cross-sectional controls for fixed effects, subgroup analysis by industry sector and credit rating categories, calculation of average regression coefficients using time-series regressions and the use of contemporaneous explanatory variables.

While results indicate that short-selling exhibits a positive relationship with CDS spreads, the question remains whether short-selling leads the CDS market or vice versa. Previous studies which examine the relationship between CDS spreads and stock markets (see *inter alia* Norden and Weber, 2009, and Forte and Pena, 2009) document that stock market returns lead CDS spread changes, suggesting price discovery occurs in the stock market more often than in the CDS market. Given short-selling occurs in the stock market, this implies that short-selling is likely to lead the

CDS market. This is consistent with the notion that short-sellers are informed (see *inter alia* Boehmer, Jones and Zhang, 2008), given the majority of price discovery occurs in the stock market. Possible explanations for stock returns leading CDS spreads could be the structural difference between the markets in which the assets are traded. The structural differences could imply probable differences in the relative speed with which respective markets respond to the changes in credit conditions. For example, CDS markets for individual firms are OTC compared to stock markets which are traded through an electronic exchange.

Several potential future research directions lead from the work in this dissertation. The results in Chapter 4 provide the first empirical evidence regarding the impact of naked short-selling on market quality. Further evidence is called for to validate and extend these findings. The ability of this research hinges on the quality and availability of naked short-selling data. The availability of intraday data on naked short-sales would allow a more precise examination at an increased granularity. The relationship between CDS spreads and short-selling, as examined in Chapter 5, is also a new area which requires further work. Further examination of the directional relationship is required to determine whether short-sales lead CDS spreads or vice versa.

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