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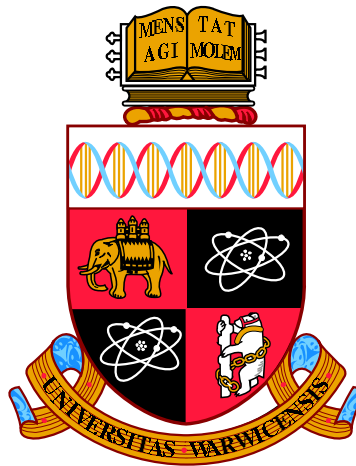
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# Essays on the Role of Short Selling in Financial Markets

by

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for the degree of

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## **Declarations**

I declare that any material contained in this thesis has not been submitted for a degree to any other university. I further declare that Chapter three of this thesis is co-authored with Dr. Chendi Zhang, and Chapter four of this thesis is co-authored with Dr. Roman Kozhan and Dr. Arie E. Gozluklu.

Linquan Chen

September 2015

## **Abstract**

The first essay (Chapter 2) examines how investors behave in parallel markets that trade the same asset but have different degrees of transparency level. Using data from the Taiwan Security Borrowing and Lending market, we find that short sellers with private information prefer to trade in the opaque market, with momentum and risk-bearing trading strategies prefer to trade in the semi-transparent market, and with urgent liquidity needs (such as short-squeezed short sellers) prefer to trade in the transparent market. We show that transactions in both transparent and opaque markets contain information and provide liquidity. Our results indicate that parallel markets complement each other by serving different types of investors.

The second essay (Chapter 3) shows that the presence of security lending supply before an initial public offering (IPO) reduces the initial stock return following IPO and improves the subsequent long-run performance. We use a sample of British firms that went public via a two-stage IPO procedure where a firm becomes publicly traded on the London Stock Exchange in the first stage, and offers new shares to the public in the second stage. Stocks are lendable before the new equity issuance which relaxes the short sale constraints that investors typically face in a conventional IPO. We find that two-stage offerings with higher security lending supply before offering are associated with lower IPO underpricing and better long-run performance. Our results are consistent with the conjecture that short selling improves the pricing efficiency of the IPO market.

The third essay (Chapter 4) examines the effect of short sellers as arbitrageurs on market liquidity in cases of toxic and non-toxic arbitrage opportunities. Arbitrage opportunities can be toxic when the prices of an asset-pair adjust to information at different speeds. In this case, market makers increase spread to avoid being picked off by informed arbitrageurs. Using price-parity deviations of Canadian stocks cross-listed in the U.S. market as arbitrage opportunities identifiers, we document that short arbitrageurs provide liquidity to the market in general, but impair liquidity in cases of toxic relative to non-toxic arbitrage opportunities. We also show that the liquidity impairment effect of short arbitrageurs is stronger when limits to arbitrage are high.

## List of Abbreviations

<b>2SLS</b>	Two-stage ordinary least square
<b>ADRs</b>	American depositary receipts
<b>AMEX</b>	American Stock Exchange
<b>AR</b>	Abnormal return
<b>B/M</b>	book-to-market ratio
<b>bps</b>	Basis points
<b>CA</b>	Canadian
<b>Characteristic-adjusted-BHAR</b>	Characteristic-adjusted three-year buy-and-hold abnormal return
<b>EWAR</b>	Equally-weighted risk-adjusted abnormal return
<b>EWRT</b>	Equally-weighted return
<b>FX</b>	Foreign exchange
<b>HGSC</b>	Hoare Govett Smaller Companies
<b>HML</b>	Value factor
<b>IO</b>	Institutional ownership
<b>IPOs</b>	Initial public offerings
<b>LIML</b>	Limited information maximum likelihood
<b>LSE</b>	London Stock Exchange
<b>Market-adjusted-BHAR</b>	Market-adjusted three-year buy-and-hold abnormal return
<b>MLE</b>	Maximum likelihood estimation
<b>NASDAQ</b>	National Association of Securities Dealers Automated Quotations
<b>NYSE</b>	New York Stock Exchange
<b>OLS</b>	Ordinary least squares
<b>OTC</b>	Over-the-counter
<b>P</b>	Stock price
<b>p.a</b>	Per annum
<b>R</b>	Stock return
<b>SP</b>	Standard and Poor's
<b>SBL</b>	Security borrowing and lending
<b>SEO</b>	Seasoned equity offering
<b>SHRAT</b>	Short interest normalized by stock trading volume
<b>SHVOL</b>	Raw short interest
<b>SIC</b>	Standard Industry Classification
<b>SMB</b>	Size factor
<b>TAQ</b>	Trade and Quote database
<b>TRTH</b>	Thomson Reuters Tick History
<b>TSX</b>	Toronto Stock Exchange
<b>TWDCC</b>	Taiwan Depository and Clearing Corporation

**TWSE**

Taiwan Stock Exchange

**UMD**

Momentum factor

**VIX**

Chicago Board Options Exchange Volatility Index

## Chapter 1

### General introduction

A *short sale* is defined by the U.S. Securities and Exchange Commission as “the sale of a stock that an investor does not own or a sale which is consummated by the delivery of a stock borrowed by, or for the account of, the investor.”<sup>1</sup> Short sellers borrow securities for delivery at settlement. Later, they purchase securities back on the open market and return to the lender to close out their short position. They earn profit if the security price decreases between the opening and closing out of the short position.

Academics generally believe that short selling is beneficial to the market. Miller (1977) predicts that in the existence of divergent opinions, short sales improve market efficiency by allowing investors with opposite opinions to short stocks, so as to reduce potential overvaluation. In addition, Diamond and Verrecchia (1987) predict that short sales enhance the adjustment speed of stock prices to negative information. Empirically, Dechow, Hutton, Meulbroek, and Sloan (2001), Boehmer, Jones, and Zhang (2008), and Diether, Lee, and Werner (2009) find that short sellers are informed traders who contribute to pricing efficiency. Moreover, Kaplan, Moskowitz and Sensoy (2013) document that stock lending as the source of short sales has no adverse effects on stock returns, volatility, skewness, or bid- ask spreads. Further, Saffi and Sigurdsson (2010) document that stocks with low lending supply have lower pricing efficiency.

However, short selling is also perceived as a cause for the 2007-2009 financial crisis and the European sovereign debt crisis. More specifically, short sellers are blamed for generating excessive volatility with large price reversals through aggressive and

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<sup>1</sup> <http://www.sec.gov/answers/shortsale.htm>

manipulative shorting behaviour (e.g., Goldstein and Guembel, 2008). With a model of predatory short selling, Brunnermeier and Oehmke (2013) predict that aggressive short sales in stocks owned by financial institutions could lead to short-term creditor-imposed leverage constraints in these financial institutions. This leverage constraint could force financial institutions (i.e., stock owners) to liquidate their long-term asset holdings at a fire sale price. Empirically, Shkilko, Van Ness, and Van Ness (2012) show that intraday predatory short sales could consume liquidity and cause excessive downward price pressure.

Recent literature that investigates short selling bans (mainly target at financial stocks) during the 2007 to 2009 financial crisis find that banning short sales may not be a successful means of market intervention. For example, by examining over 12,600 stocks from 26 markets, Beber and Pagano (2013) find that short selling bans impair liquidity and reduce price correction speed. Similarly, by studying the short selling ban in the U.S. market, Harris, Namvar and Phillips (2013) and Boehmer, Jones, and Zhang (2013) document that the prices of financial stocks are inefficiently inflated during the ban. In addition, by studying the short selling ban in the U.K., Marsh and Payne (2012) show that both liquidity and market efficiency decrease for financial stocks during the ban.

The above literature indicates that a thorough understanding of short sales and related markets is crucial to academics, regulators and investors. This thesis contains three empirical essays that examine the role of short selling in the financial market from different settings. Specifically, Chapter 2 investigates short sales in parallel markets with different levels of transparency, based on the data from Taiwanese security borrowing and lending (SBL) market. In the Taiwan SBL market, the following three markets run in parallel: (i) a transparent market, which facilitates both pre-trade and

post-trade transparency, (ii) a semi-transparent market, which provides post-trade transparency, and (iii) an opaque market that does not provide any quote or trade level information.

Academics have undertaken several studies, but both the theoretical and empirical literature remain inconclusive about the effect of transparency on market quality (e.g., Pagano and Röell 1996, Rindi, 2008, Madhavan, Porter, and Weaver 2005; and Boehmer, Sarr and Yu, 2005). The results in Chapter 2 show that markets that trade the same asset but have heterogeneous levels of transparency complement each other by catering for investors with different trading needs. In addition, Chapter 2 documents that short interests (lending fees) in the opaque (transparent) market have strong predictive power regarding future stock returns, while short sales in the semi-transparent market have no predictive power. Further, Chapter 2 shows that short sales in both transparent and opaque markets provide liquidity to the stock market, while short sales in the semi-transparent market have no significant impact on stock liquidity.

Chapter 3 analyses the effect of relaxing short sale constraints on the performance of initial public offerings (IPOs) based on a sample from the London Stock Exchange (LSE). On the LSE, firms could go public via a two-stage IPO strategy (i.e., introduction) which has the same regulatory requirements as a conventional one-stage IPO, but allows issuers to separate the listing (i.e., the first-stage introduction) and equity issuance (i.e., the second-stage offering) into two stages. In the first-stage introduction, firms are listed on the LSE without raising new capital, while in the second-stage offering, listed firms raise capital by issuing new shares. Importantly, existing shares could be borrowed and sold short immediately after the first-stage introduction. When there exists a stock lending supply after the first-stage introduction, the second-stage equity issuance

becomes short sale unconstrained. Short sellers would short existing shares before the second-stage offering day if they believe stocks are overpriced, which in turn would reduce the upward price pressure on the second-stage offering day. Consequently, among two-stage IPO firms, short sale unconstrained firms are expected to have less price run-up on the second-stage, offering day and better performance in the long-run.

The results in Chapter 3 show that the presence of short sellers before an IPO reduces the first-day IPO return and improves the long-run stock performance. Theoretical studies predict that short sale constraints and opinion dispersion on the IPO offering day could be associated with initial price run-up and subsequent long-run underperformance (e.g., Miller, 1977). However, in conventional IPOs, short sale supply is unobservable since data on stock lending supply are only available for publicly listed stocks. Using a novel sample with pre-IPO short sale supply data, Chapter 3 directly tests this prediction and find supporting evidence.

Chapter 4 studies the effect of short sellers as arbitrageurs on market liquidity in heterogeneous arbitrage opportunities. The previous literature examines the effects of arbitrage on market liquidity, and has mixed predictions: Holden (1995) and Gromb and Vayanos (2002, 2010) predict that arbitrageurs provide liquidity to the market when they correct the mispricing based on transient buying pressure. Foucault, Röell, and Sandås, (2003) conjecture that when arbitrageurs trade with asymmetric information, they impair market liquidity as dealers increase spread to avoid being picked off at stale quotes. In addition, Foucault, Kozhan, and Tham (2015) posit that arbitrageurs have different effects on market liquidity depending on the source of arbitrage opportunities.

Chapter 4 provides evidence on the heterogeneous effects of short sales on market liquidity based on arbitrage opportunities among Canadian stocks that are cross-listed in



the U.S. market. A cross-listing arbitrage opportunity arises when prices in the U.S. and Canadian markets deviate from each other. Arbitrageurs simultaneously take a short position in the relatively overpriced market and a long position in the relatively underpriced market. The findings in Chapter 4 indicate that short arbitrageurs provide liquidity to the cross-listed stocks in general. However, they may impair liquidity in cases of toxic (i.e. arbitrage opportunities that arise because of asynchronous adjustments to news) relative to non-toxic arbitrage opportunities (i.e. arbitrage opportunities that arise because of liquidity shocks), and this liquidity impairment effect is stronger among firms with higher arbitrage costs.

## **Chapter 2**

### **Short selling in parallel markets with different transparency**

#### **2.1. Introduction**

Market transparency is regarded as central to the financial market. Different transparency levels result in heterogeneous rent distributions among market participants. Undesirable transparency level could even drive certain types of investor out of the market (Foucault, Pagano, and Röell, 2013). In addition, the transparency level is also crucial to the competitiveness of exchanges. For example, in order to compete with dark pools for market share, the New York Stock Exchange (NYSE) launched a pilot program in October 2008 which allows investors to hide all of their order sizes. Academics have undertaken several studies, but both the theoretical and empirical literature remain inconclusive about the effect of transparency on market quality (e.g., Pagano and Röell 1996, Rindi, 2008, Madhavan, Porter, and Weaver 2005; and Boehmer, Sarr and Yu, 2005).

In this paper, we examine the Taiwanese security borrowing and lending (SBL) market, in which the following three markets run in parallel: (i) a transparent market, which facilitates both pre-trade and post-trade transparency, (ii) a semi-transparent market, which provides post-trade transparency, and (iii) an opaque market that does not provide any quote or trade level information. Based on this novel setting, we examine the trading behaviours of investors with heterogeneous trading motivations. We document that parallel markets with different transparencies complement each other and serve investors with different trading needs.

With the aforesaid parallel markets being heterogeneous in transparency, an informed investor with private information may prefer to trade in the opaque market to hide his information. However, if the broker in the opaque market also has information, he will increase trading costs or stop trading with informed investors. As private information is usually time-sensitive, the informed trader will then need to shift to the transparent market for the fastest execution to avoid closing his position. In addition, uninformed investors such as momentum and opportunistic risk-bearing traders would prefer to trade in the semi-transparent market, in which they could better evaluate the equity based on past trading information, while bearing search costs to avoid paying a higher price for immediacy.

In this paper, we focus on the behaviour of security borrowers in the Taiwanese SBL market. Security borrowers are mainly short sellers who are perceived as sophisticated traders (Boehmer, Jones, and Zhang, 2008; Engelberg, Reed, and Ringgenberg, 2012; and Boehmer and Wu, 2013) that trade with different strategies (Diether, Lee, and Werner 2009).<sup>2</sup> Their trading behaviours could provide insights into how investors optimize their trading needs by choosing among markets with different levels of transparency.

The Taiwan SBL markets offer a suitable economic setting in which to investigate the relation between market transparency and investor behaviour. First, the Taiwan Stock Exchange (TWSE) is an important market in emerging economies, with its total market capitalization ranked 21st in the world. Second, Taiwan is one of the few countries (e.g., Singapore, Brazil and Japan) with parallel SBL systems, and it offers investors three different levels of market transparency. Third, Taiwan is the only market

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<sup>2</sup> There could be other purpose of security borrowing except for short selling, for example, borrowing shares for voting. However, these trades are not prevalent and only emerge around particular event days.

that provides trade-level SBL information in the transparent and semi-transparent markets. This unique data enables us to examine the informativeness of lending fees paid by short sellers with different trading motivations.

We raise several important findings. First, we provide real market evidence of trading protocols in parallel markets with different transparencies. We show that during our sample period, the opaque market neither overrides (e.g., Madhavan, 1995) nor gets crowded out by more transparent markets (e.g., Chowdhry and Nanda 1991). Our results support the experimental findings by Bloomfield and O'Hara (2000) which show that parallel markets with different levels of transparency could arrive at equilibrium. We further demonstrate that different transparent levels attract investors with different trading motivations.

Second, we document different degrees of informativeness from short sales in the three markets. We show that lending volume (lending fees) in the opaque (transparent) market have strong predictive power regarding future stock returns, while short sales in the semi-transparent market have no predictive power. Finally, we document that short sales in both transparent and opaque markets provide liquidity to the stock market, while short sales in the semi-transparent market have no significant impact on stock liquidity.

Our paper contributes to the growing finance literature that examines market transparency and multi-market trading (e.g., Biais, 1993; Lyons, 1996; Porter and Weaver, 1996; and Bloomfield and O'Hara, 1999). Previous literature mainly focuses on the trading patterns of dealers and informed traders (Chowdhry and Nanda, 1991; Biais, 1993; Porter and Weaver, 1996; and Hansch, Naik, and Viswanathan, 1998) and relies on experimental asset markets (Bloomfield and O'Hara, 1999, 2000; Bloomfield, O'Hara, and Saar, 2015; and Gozluklu, 2014). We extend this literature by identifying

various types of investor with different trading motivations in the Taiwanese SBL market, and analyze how they trade in parallel markets with heterogeneous transparencies. We also document that when markets with different transparencies coexist, each market affects stock returns and liquidity differently. To the best of our knowledge, this is the first study that uses real market data to examine investors' trading behaviour in three parallel markets with heterogeneous market transparencies.

In addition, this is also the first paper to investigate a parallel SBL market system. Unlike conventional short selling literature that focuses on a single over-the-counter (OTC) market (e.g., Kolasinski, Reed, and Thornock, 2013, Saffi and Sigurdsson, 2010, and Prado 2015), we use a novel sample in the Taiwanese SBL market to directly track lending fees for the same asset in parallel markets. In contrast to the previous literature which predicts that increasing transparency could reduce the search cost and thus result in lower lending fees (Duffie, Gârleanu, and Pedersen, 2002; Yin, 2005), we document a higher average lending fee in the transparent market (2.97% p.a.) compared to that in the semi-transparent market (1.24% p.a.). We conjecture that when investors can choose among markets in different transparency regimes, the higher lending fee in the transparent market is likely to represent the cost of immediacy.

Moreover, we fill in an important gap in the short selling literature by revealing the heterogeneous preferences of different short sellers for market transparencies. The previous literature with a single OTC market setting could only examine the general influence of market transparency on short sellers based on changes in disclosure requirements (Jones, Reed, and Waller, 2014; Duong, Huszár and Yamada, 2015). We provide direct evidence from the parallel Taiwanese SBL markets, and show that different transparencies benefit short sellers with different trading needs.

The rest of our paper proceeds as follows: Section 2 describes the institutional features of the Taiwan SBL market. Section 3 develops hypotheses. Section 4 describes our sample and summary statistics. Section 5 presents empirical results. Section 6 concludes.

## **2.2. Institutional features**

### **2.2.1. Taiwan SBL market**

In Taiwan, naked short selling is prohibited. Investors short sell either within the credit line of a margin account, or by borrowing sufficient stocks from the SBL market. The Taiwanese SBL market operates a three tiers system, where a transparent market (a market for “competitive bid transactions” as defined by the TWSE), a semi-transparent market (a market for “negotiated transactions” as defined by the TWSE), and an opaque market (a market for “brokerage transactions” as defined by the TWSE) run in parallel.

Both the transparent and semi-transparent markets were established by the TWSE in June 2003. The transparent market uses a deal-matching principle with the lending fee determined by bids and offers through the SBL system. The trading process of transactions in the transparent market is illustrated in Figure 2.1. When a deal is matched, TWSE requests Taiwan Depository & Clearing Corporation (TWDC) to transfer the loaned securities from the borrower to the lender. Specifically, both the borrower and lender appoint a security firm to report their bids and offers to the TWSE. TWSE acts as a central counterparty and handles collaterals. The initial collateral margin is fixed at 140% of the stock value, measured by its market opening price. In the event of default, TWSE uses the provided collateral to buy back loaned securities. Moreover, trading in the transparent market will incur the following trading costs:

lending fee (as determined in the transaction), TWSE service fee (which accounts for 1.6% of the determined lending fee), and the security firms' commissions (which accounts for 0.4% of the determined lending fee). All fees are calculated on a trade-by-trade basis.

The trading process of transactions in the semi-transparent market is illustrated in Figure 2.2. In particular, borrowers and lenders negotiate through their appointed security firms and agree on a negotiated borrowing contract. The contract needs to be confirmed by TWSE. After confirmation, TWSE then requests that TWDCC transfer the loaned securities. In addition, both initial collateral margin and maintenance margin are negotiated between the borrower and lender. The delivery of collateral is also arranged between the SBL counterparties. Therefore, the default risk of the borrower is borne by the lender. Trading costs in the semi-transparent market include lending fees (which is negotiated between the borrower and lender), the TWSE transaction fee (which accounts for 0.02% per annum of the total lending value) and security firms' commissions (which is negotiated between the SBL participants and security firms).

The opaque market started in January 2007. Transactions under this scheme are completed outside the TWSE SBL system. The opaque market follows an OTC setting, in which participants are not required to disclose any information to the public. Moreover, no intermediary exists in the opaque market, borrowers and qualified brokers (security firms and security finance companies who hold a lending pool) search for each other and negotiate on lending volume, lending fee and commission for each SBL transaction (as illustrated in Figure 2.3). Collaterals are arranged between the borrower and the broker, while the initial collateral margin is fixed at 140% of the stock value measured by its market opening price. The default risk of the borrower is borne by the

broker. Trading costs in the opaque market include lending fees and commissions (both are negotiated between the borrowers and brokers).

### **2.2.2. Transparency in parallel SBL markets**

In this section, we describe the types of information that each market discloses. The transparent market provides both pre-trade and post-trade transparencies. In terms of pre-trade transparency, live competitive bids and offers in the transparent market are updated on the TWSE website during trading hours. Moreover, the identity of each order submitter is disclosed to the public. This pre-trade information could limit investors' execution risk and reduce the search cost. In terms of post-trade transparency, lending volume and lending fees are reported on the TWSE website immediately after the completion of each transaction. This post-trade information could help market participants evaluate the value of securities.

The semi-transparent market provides post-trade transparency. Borrowers need to appoint a security firm to search for and bargain with potential lenders. Therefore, they bear the search cost. During the searching and negotiation process, no information on quotes is disclosed to the public. After a trade in the semi-transparent market is settled, TWSE immediately reports the associated lending volume and lending fee on its website. However, the identity of traders is not disclosed.

The opaque market is the least transparent market. No quote or trade-level information is available to the public. Borrowers and brokers need to search for each other and bargain on the lending fees. TWSE collects information from each broker on a daily basis, and then estimates a total daily lending volume in all the three SBL markets for each stock. This estimation would be published on the TWSE website the following



day, from which investors could infer the historical lending volume in the opaque market.

### **2.2.3. Security lending volume versus short interest**

In this section, we describe the distinction between security lending volume and short interest. A conventional proxy for short selling activity is short interest. It measures the total open short positions at the end of each trading day. Although short interest captures the flow of a completed loan, it masks the sources and costs associated with the loan. In comparison, security lending volume measures total shares on loan at the end of each trading day. It captures the flow of a new loan position and identifies the market in which it is borrowed from. Since there are three parallel markets for stock borrowing in Taiwan, a new loan position in one market could either represents a new opening of a short position or a shift of an existing short position from another market. Therefore, security lending volume provides a more comprehensive understanding of trading strategies of short sellers.

## **2.3. Hypothesis development**

Our main research question focuses on the trading behaviour of heterogeneous short sellers in the presence of parallel SBL markets with different transparencies. The previous literature shows that short sellers could have different trading strategies (Diether, Lee, and Werner, 2009). In this section we discuss various types of short

selling motivation on which we focus and make predictions on the possible preferences of corresponding short sellers on market transparency.<sup>3</sup>

The first motivation for short selling is short sellers' possession of asymmetric information. Informed short sellers could have private information about either the contemporaneous or future stock fundamental values. Short sellers would short sell stocks that are either temporarily overpriced (Miller, 1977) or have not incorporated asymmetric information about future fundamental values into current prices (Diamond and Verrecchia, 1987). In addition, according to Engelberg, Reed, and Ringgenberg (2012), market capitalisation could proxy for information asymmetry. Since news coverage and investor attention decrease with firm size, information asymmetry would be severer among small stocks (Vega, 2006; Engelberg, 2008). Therefore, to identify information based short sales, we examine whether lending volume is higher in small stocks, and have predictive power on future stock returns.

The literature on market transparency predicts that informed investors would prefer to trade in the opaque market. In particular, Chowdhry and Nanda (1991) predict that informed traders prefer trading in a less transparent market to dissimulate their private information. Likewise, Pagano and Röell (1996) argue that informed dealers prefer trading in opaque market to better extract rents from less informed investors in opaque market. Further, Madhavan (2000) claims that traders with private information prefer trading in an anonymous system to avoid being identified as informed and charged with

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<sup>3</sup> One should note that as short sellers are not all alike, there could be other short selling motivations beside the ones we investigate here. For example, short arbitrage based on corporate events, short arbitrage based on convertible bonds and indexes, and short sale to hedge a long position in the same stock. These short sale motivations are beyond the scope of this paper, however, they would be worth studying in the future research.

wider spread. We conjecture that these predictions can be extrapolated to the setting with parallel SBL markets. Formally we posit:

*H1: Lending volume in the opaque market have predictive power on future stock returns.*

The second motivation for short selling is to resolve a “short-squeeze” problem. A short-squeeze occurs when a security lender wants to sell the loaned stock and recalls it from the short seller. Consequently, the short seller needs to find an alternative lender. In the worst case, he has to repurchase the stock from the open market and close his short position.

When a security lender recalls a stock, the short seller has to deliver the stock in a limited time (usually within three days) and in turn, has to pay a high lending fee to another lender for immediacy (D’Avolio, 2002). As the starting day of the short-squeeze based short sale transaction does not represent the real opening date of the short seller’s position, the lending volume of the new transaction may still represent short seller’s past information (information short seller possessed on the real opening date of this short position). Rather, the high lending fee in a short-squeeze based transaction could contain the lender’s private information on the stock’s future performance, as it represents a decrease in the lending supply. Huszár, Tan, and Zhang (2015) show that lenders are large institutional owners (insiders) that have better information about the stock but are prohibited from selling. They document that lenders raise lending fees and recall stocks before negative earnings announcement to deter upcoming short sales. If the short-squeeze based short sale reveals lender’s private information, then the lending fee would have prediction power for future stock return even after controlling for the short sale demand (i.e., short interest). Therefore, to identify a short-squeeze based trading, we

examine whether lending volume has limited predictive power on future stock returns, and whether lending fees associated with these trades have strong predictive power for future stock performances.

In addition, Bloomfield and O'Hara (1999) show that traders with immediate liquidity needs cannot conceal their needs and will be charged higher price by market makers in a transparent market. Since short-squeezed short sellers need to deliver stocks back to the original lender in limited time, they need to trade in the transparent market which has no search cost but high borrowing cost. Formally, we posit:

*H2: Lending fees in the transparent market have predictive power on future stock returns.*

The third motivation for short selling is to facilitate momentum trading. The previous literature documents that investors earn profit by buying stocks with good past performance and selling stocks with poor past performance (Jegadeesh and Titman, 1993, 2011; Chan, Jegadeesh, and Lakonishok, 1996). In addition, Konukoglu (2010) shows that momentum traders are uninformed and trade based on the past profitability of momentum factors. Therefore, to identify momentum based trading, we expect that lending volume increases as the stock past performance decreases, and are more likely to crowd in past losers (i.e. stocks with the poorest past performance).

The forth motivation for short selling is to facilitate opportunistic risk-bearing trading. As predicted by Miller (1977), uncertainty and risk lead to opinion dispersion. In the presence of opinion dispersion, pessimistic investors would bear the risk and short the stock. Empirically, opinion dispersion could be captured by stock intraday volatility (Diether, Lee, and Werner, 2009). Therefore, to identify opportunistic risk-bearing short

selling, we expect that lending volume increases following the increase in stock intraday volatility.

For short sellers with momentum and opportunistic risk-bearing trading strategies, the literature shows that they are likely to be uninformed (e.g., Miller, 1977; Konukoglu, 2010). Therefore, instead of focusing on one particular stock that they have information on, they are more likely to first select several potential targets and then search and bargain to pick up ones with the lowest lending fees. In the semi-transparent market, they could easily evaluate the lending fees and availabilities of a set of stocks. Therefore, we conjecture that momentum and risk-bearing traders prefer to trade in the semi-transparent market. Formally, we posit:

*H3: lending volume and lending fees in the semi-transparent market have no predictive power on future stock returns.*

#### **2.4. Sample and descriptive statistics**

In this section, we describe our data sets and present the characteristics of the three SBL markets. We use data from multiple sources. We hand collect transaction-level security lending volumes and SBL fees from the TWSE web site for the transparent and semi-transparent markets during our sample period (January 2010 to December 2013). To infer the daily lending volume of each stock in the opaque market, we obtain daily total lending volume of each stock from TWSE. Since SBL transactions can only be conducted in these three markets, the stock-level daily lending volume in the opaque market is estimated as the difference between the daily total lending volume and the combined daily lending volume in the transparent and semi-transparent markets. In addition, we obtain bid, ask, and closing prices, trading volume, total outstanding shares,

year-end book value of equity and deferred taxes from Compustat Global and Datastream. We obtain institutional ownership data from the Taiwan Economic Journal. We exclude firms without SBL transactions.

Our sample contains 1,045 common stocks that are listed on the TWSE or Gre Tai during the January 2010 to December 2013 period. Among these 1,054 firms, 342 firms are traded in the transparent market, 692 firms are traded in the semi-transparent market, and 1,049 firms are traded in the opaque market. In addition, the majority of firms traded in the transparent market are also traded in the other two markets. Likewise, most firms traded in the semi-transparent market are simultaneously traded in the opaque market. Overall, the total number of stocks that are traded in all three markets is 323.

Table 2.1 reports the distribution of SBL transactions in each market during our sample period. The number of trades in both the transparent and semi-transparent markets increases from 2010 to 2013. However, the total lending volume in the transparent market decreases continuously during our sample period. This finding indicates that traders in the transparent market prefer more frequent and small trades to infrequent large trades.

Panel A of Figure 2.4 illustrates the percentage market share of each SBL market measured by total lending volume. We find that the transparent market experienced a 9% drop in market share in 2011. This decrease occurred right after the financial crisis. During recessions, investors are more aware of default risk. Therefore, with TWSE acting as a central counterparty (i.e., investors have minimum default risk), the transparent market was favored by investors at the beginning of our sample. However, with the recovery of stock market after the financial crisis, the benefits of having a central counterparty become less attractive for investors.

To the contrary, semi-transparent market experienced a steady increase in market share, from 48.35% in 2010 to 65.41% in 2013, as measured by total lending volume. The opaque market has a relatively stable market share, between 18.6% and 24.11% during our sample period. This evidence suggests that short sellers who leave the transparent market generally flow into the semi-transparent market. If the quote information is ineffective in influencing market behaviour (Bloomfield and O'Hara, 1999), then the trade flow from the transparent market to semi-transparent market represents a decline in investors' utility on default risk guarantee after the financial crisis. For robustness, we use total lending value as an alternative measure of market share and find similar patterns, as plotted in Panel B of Figure 2.4.

Figure 2.5 presents the average lending fee in transparent and semi-transparent markets. During our sample period, the average lending fee in the transparent market is more than twice as high as that in the semi-transparent market. This finding contradicts the previous literature which predicts that higher transparency could reduce search costs (Yin, 2005) and thus result in lower lending fees (Duffie, Gârleanu, and Pedersen, 2002). However, the high lending fee in the transparent market could be anticipated with parallel markets. When short sellers can choose from markets with different transparencies, traders opting for the most transparent market are likely to be in urgent needs and cannot afford time to search in the semi-transparent or opaque market. Therefore, borrowers may not have bargaining power on lending fees.

Table 2.2 presents the summary statistics of stocks traded in each SBL market. Specifically, we report the raw lending volume (*SHVOL*), normalized lending volume (*SHRAT*), institutional ownership (*IO*), market capitalization, turnover, intraday volatility, return volatility, *Amihud illiquidity*, and book-to-market ratio (*B/M*). For

comparison, we also report the summary statistics for the full sample. *SHVOL* is the total lending volume measured in thousands. *SHRAT* is calculated as the ratio of daily lending volume to daily trading volume, measured in percentage.<sup>4</sup> As suggested by Boehmer, Jones, and Zhang (2008), this normalization ensures the cross sectional comparability of lending volume. *Amihud illiquidity* is our main proxy for stock liquidity, which is measured as the ratio of absolute daily percentage return to daily dollar trading volume (Amihud, 2002). *B/M* is measured as the book value of equity divided by the market value of equity. *IO* is the percentage of shares outstanding owned by institutional investors. *Capitalization* is the price per share times the shares outstanding. *Turnover* is the total trading volume divided by shares outstanding, measured in percentage. *Intraday volatility* is the difference between daily high and low price, divided by the daily high price and measured in percentage. *Return volatility* is the standard deviation of daily stock returns over the previous month.

We find that the semi-transparent market has the highest average daily lending volume by using both lending volume measures. In addition, the transparent and opaque markets have similar *SHVOL* (13.47 vs. 13.02), while the *SHRAT* is slightly higher in the opaque market. The relatively lower *SHRAT* in the transparent market may be explained by the larger average capitalization and higher turnover in this market. Stocks traded in the transparent market also have the highest level of institutional ownership.

Moreover, the transparent market has the lowest *Amihud illiquidity* (0.09%) while the opaque market has the highest (0.41%). This evidence indicates that stocks traded in the transparent market are liquid stocks, while stocks traded in the opaque market are illiquid stocks. This evidence is also consistent with D’Avolio (2002), who documents

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<sup>4</sup> All our results remain similar if we normalize short sale volume with total shares outstanding.



that the holdings by security lenders are more biased towards large, liquid stocks than the average holdings by institution investors in general. Therefore, we conjecture that security lenders in the Taiwanese market are mainly passive indexers, similar to those in the U.S. market.

## **2.5. Empirical analysis**

### **2.5.1. Determinants of short sales in parallel markets**

Evidence of different short sale motivations could be inferred from determinants of short sales in the three parallel markets. To avoid sample selection bias, we focus on the 323 stocks that have been traded in all the three markets. We run a weekly panel regression with firm fixed effect to test the determinants of short sales in each market. The dependent variable *SHRAT* is converted from daily into weekly by taking the Wednesday to Wednesday average. The same conversion method applies to other variables. Independent variables include: lagged return (*R*), which is estimated by aggregating Wednesday to Wednesday percentage daily returns; *winner (loser)*, which is a dummy variable that equals to one if the stock return is ranked in the top (bottom) decile in that week, and zero otherwise; *intraday volatility*, *turnover*, *IO* and *capitalization*. In addition, since lending volume has autocorrelation, we include lagged *SHRAT* in the three markets as independent variables.

Table 2.3 presents the estimation results. Column (1) and (2) report the determinants of lending volume in the transparent market. Specifically, lagged *winner* is positively associated with *SHRAT* in Column (2), which indicates that short sellers in the transparent market are either contrarian traders or have emergent needs for stocks (i.e., short-squeezed). If the transparent market is dominated by contrarian traders, both

lending volume and lending fees should have (no) predictive power on future stock return when contrarian short sellers are informed (uninformed). In contrast, if the transparent market is dominated by short-squeezed short sellers with emergent trading needs, only lending fees could have predictive power on future stock returns. Therefore, to further identify the dominant trading motivation in the transparent market, we need to explore the predictive power of lending volume and lending fees on future stock returns. Further, *SHRAT* is negatively correlated with *Amihud illiquidity* in the previous week in both regressions, which indicates that liquid stocks are more likely to be sold short in this market. This is consistent with our finding in Table 2.2 that stocks available in the transparent market are liquid stocks.

Column (3) and (4) of Table 2.3 report the determinants of lending volume in the semi-transparent market. We identify strong risk-bearing and momentum trading motivations in this market. Economically, in Column (3), a one standard deviation (i.e., 4.71%) increase in past return is associated with a 0.14% decrease in *SHRAT*. Similarly, the coefficient of lagged *loser* is significantly negative in Column (4). These findings show that momentum short sellers prefer to trade in the semi-transparent market, which supports *H3*.

In addition, the coefficients of lagged *intraday volatility* are positive in both Columns (3) and (4). Economically, a one standard deviation (i.e., 1.27%) increase in *intraday volatility* in the previous week would lead to a 0.10% and 0.13% increase in *SHRAT* in Columns (3) and (4), respectively. This result indicates that the lending volume in the semi-transparent market increases with the level of uncertainty. This evidence shows that opportunistic risk-bearing short sellers prefer to trade in the semi-transparent market, which supports *H3*.

Columns (5) and (6) present the estimation results of short sale determinants in the opaque market. The positive coefficient of lagged return in Column (5) and the negative coefficient of lagged *winner* in Column (6) indicate that short sellers avoid past winners. However, they do not concentrate on past losers, which indicate that short sellers in the opaque market may not be simply momentum traders. In addition, the coefficients of *capitalization* are negative in both Columns (5) and (6), which indicates that short sellers in the opaque market prefer small stocks (i.e., stocks with high information asymmetry).

### **2.5.2. Information and return predictability in parallel markets**

To test which market has more informed short sellers, we form portfolios based on lending volume and examine the performance difference between the least shorted stocks (portfolio 1) and the most shorted stocks (portfolio 5). According to Boehmer, Jones, and Zhang (2008), the portfolio approach is easy to interpret, as it replicates the return to a real trading strategy. Moreover, portfolio sorting approach could reduce the impact of outliers when compared to the regression approach. We expect portfolio 5 to underperform portfolio 1 if the market has informed investors. In addition, we also consider an overall sorting based on daily aggregated lending volume from all the three markets. This provides an assessment of the average informative level of transactions in the Taiwanese SBL market. To better replicate the real portfolio trading strategy, we start by sorting all stocks that are traded in each market. In the robustness test, we also provide sorting results in each market based on the 323 stocks that have been traded in all three markets.

Following Boehmer, Jones, and Zhang (2008), each day we sort stocks within each parallel market into quintiles based on the *SHVOL* and *SHRAT* in previous five days. We then skip for one day and hold the portfolio for (i) one week (i.e., five trading days) to replicate a short-term holding strategy, and (ii) one month (i.e., twenty trading days) to replicate a long-term holding strategy. We repeat the sorting and holding procedure for each day, which indicates that the holding portfolio is rebalanced by 1/5 or 1/20 on each holding day. Finally, we calculate the average daily returns for the two holding strategies following a calendar-time approach and report the results by multiplying five (twenty) to illustrate the real profit of the portfolio strategy. The short-term and long-term holding strategies help us to capture the time effectiveness of information, if exists, processed.

Table 2.4 reports the sorting results. The portfolio performance is measured by both equally-weighted daily raw return (*EWRT*) and equally-weighted risk-adjusted daily abnormal return (*EWAR*), measured in basis points (bps).<sup>5</sup> The risk-adjusted daily abnormal return (i.e., risk-adjusted AR) is measured as the difference between stock return and the return of a corresponding Fama-French (Fama and French, 1993) 25 size/book-to-market portfolio.

Panel A reports the sorting results based on aggregated lending volume in the Taiwanese market. We find that when portfolios are sorted by *SHVOL*, *EWRT* decreases monotonically from portfolio 1 to portfolio 5, regardless of holding periods. The results remain similar when we use *SHRAT* as the sorting variable and hold each portfolio for 5

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<sup>5</sup> Our results remain similar if we use value-weighted return measures.

days. However, the return difference between portfolios 1 and 5 becomes insignificant when we increase the holding period to 20 days.<sup>6</sup>

Collectively, short sellers in general are informed in the Taiwanese SBL market, which is similar to the informativeness of short sellers in the U.S. market (e.g., Boehmer, Jones, and Zhang, 2008; 2013; and Diether, Lee, and Werner 2009). However, the information content diffuses in a longer holding period.

Next, we examine the informativeness of short sales in the three parallel markets. Panel B of Table 2.4 reports portfolio sorting results for the transparent market. We find that the performance difference between portfolios 1 and 5 is not significantly different, regardless holding periods and sorting criteria. This evidence suggests that short sales in the transparent market are not likely to be information-driven, which rules out the informed contrarian trading explanation for trading motivation in the transparent market.

Panel C reports portfolio sorting results for the semi-transparent market. Similar to the results in Panel B, we find that portfolios 1 and 5 do not have significantly different performance, regardless of holding periods and sorting criteria. This finding supports *H3*, namely that lending volume in the semi-transparent market has no predictive power on future stock returns. Uninformed investors such as momentum and opportunistic risk-bearing short sellers prefer to trade in the semi-transparent market.

Panel D reports the portfolio sorting results for the opaque market. In contrast to the transparent and semi-transparent markets, portfolio 5 significantly underperforms portfolio 1 under all performance measures, sorting criteria, and holding periods. These findings suggest that traders in the opaque market are highly informed, which is

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<sup>6</sup> The t-statistics of portfolio return differences are estimated using Newey-West (1987) adjusted standard errors with 5 lags for the short-term holding strategy and 20 lags for the long-term holding strategy.

consistent with *HI*, namely that lending volume in the opaque market has predictive power on future stock returns.

In the next test, we perform Fama and Macbeth (1973) regressions to control for other characteristics. The depended variables are *R* and *risk-adjusted AR* over the next one, two and four weeks. Independent variables include *SHRAT* in the three parallel markets; *three markets* which is a dummy variable that equals to one if the stock has positive trading in all the three markets during that week, and zero otherwise; *lending fee* in the transparent and semi-transparent markets, which is calculated by estimating the Wednesday to Wednesday value-weighted average of the lending fee in each trade within that market. Other control variables include *winner*, *loser*, *Amihud illiquidity*, *B/M*, *capitalization* and *turnover*. Standard errors are adjusted for autocorrelation by using the method in Newey and West (1987). We use 6 lags as suggested by the Akaike Information Criterion (AIC) test.

Regression results are reported in Table 2.5. Panel A reports the estimation results when raw return is used as the dependent variable. Columns (1), (3), and (5) show that, economically, a one standard deviation increase (i.e., 0.01%) in *SHRAT* in the opaque market is associated with a 0.07, 0.13, and 0.19 basis points decrease in raw return over the following one, two, and four weeks. Results are similar after including control variables, as reported in Columns (2), (4) and (6). In addition, the estimation results are quantitatively similar when risk-adjusted *AR* is used as the dependent variable as reported in Panel B. Overall, these findings suggest that the opaque market is dominated by informed short sellers, which supports *HI*.

Moreover, we find that in the transparent market, *SHRAT* has the predictive power on stocks returns in the following two and four weeks (as shown in Columns (4) to (6) in

Panel A). However, the predictive power becomes weak when we use *risk-adjusted AR* as performance measure (as shown in Panel B). In addition, we find that the lending fee in the transparent market has predictive power on stocks returns. For example, a one standard deviation (1.71% p.a.) increase in transparent market's lending fee would lead to a 6.41 bps, 16.76 bps and 33.82 bps decrease in return over the following one, two and four weeks. Results are virtually unchanged when *risk-adjusted AR* is used as performance measure (as shown in Panel B).

This strong return predictive power of transparent market's lending fee together with the weak return predictive power of lending volume in the transparent market suggest that the information in the transparent market transactions is more likely to originate from security lenders. This finding rules out the uninformed contrarian trading explanation for the trading motivation in the transparent market, and further supports *H2* by showing that short-squeezed short sellers prefer the transparent market.

The coefficients of both *SHRAT* and *lending fee* in the semi-transparent market are insignificant in Table 2.5. This result suggests that short sellers in the semi-transparent market are not likely to be informed. Consistent with *H3*, we document that neither lending volume nor lending fees in the semi-transparent market have predictive power on future stock returns.

### **2.5.3. Liquidity provision by short sales in parallel markets**

In this section we examine the liquidity provision by short sellers in parallel markets. One strand of literature shows that short sellers provide liquidity (e.g., Chakrabarty, Moulton, and Shkilko, 2012; Boehmer, Jones, and Zhang, 2013). In contrast, Comerton-Forde, Jones and Putniņš (2015) predict that short sellers could consume liquidity. We

run a panel regression with firm fixed effect to examine the relation between short sales in parallel markets and future stock liquidity.

Table 2.6 reports our estimation results. We find no significant liquidity impairment effect in any of the parallel market during our sample period. In Columns (1), (2), (5), and (6), we find that *SHRAT* in the transparent and opaque markets have negative influences on *Amihud illiquidity* over the next week. This finding indicates that short sales in the transparent and opaque markets provide liquidity to the stock market. The liquidity provision effect in both marks remains significant in Columns (7) and (8) when we simultaneously include *SHRAT* in all the three parallel markets as independent variables. Meanwhile, we find that short sales in the semi-transparent market have no significant influence on stock liquidity.

Recall that in Table 2.3 we find short sellers in the opaque market tend to trade on smaller stocks, the liquidity provision effect of short sales in the opaque may imply that informed short sellers facilitates liquidity in small stocks. In addition, the liquidity provision effect of short sales in the transparent market might represent the original lender's selling behaviour. This further supports *H2* by showing that when lenders recall stocks for sell, short-squeezed short sellers prefer to trade in the transparent market.

Based on the findings above, we conclude that short sellers with different trading motivations have different liquidity provision abilities. Informed short sellers in the opaque market and short-squeezed short sellers in the transparent market provide liquidity to the stock market. In addition, short sales based on momentum and risk-bearing trading strategies in the semi-transparent market have no significant influence on stock liquidity. Our finding further suggests that parallel markets with different



transparencies are likely to complement each other and serve investors with different trading needs.

#### **2.5.4. Robustness tests**

In this section we report the robustness test for our portfolio sorting results. Table 2.7 reports the return differences of short sale portfolios for the 323 stocks that have been traded in all the three markets. Results remain similar to those reported in Table 2.4. In the opaque market (Panel D of Table 2.7), when *EWAR* is used as the performance measure, portfolio 5 significantly underperform portfolio 1 with a 20-day holding strategy (-123.80 bps and -100.60 bps based on *SHVOL* and *SHART* sorting, respectively). The magnitude of portfolio return difference is greater than that reported in Panel D of Table 2.4 (-86.00 bps and -43.40 bps). This finding indicates that when short sellers are not restricted by specific stock characteristics and have the discretion to choose from markets in different transparency regimes, the informativeness of lending volume in the opaque market is stronger. This finding further supports *H1* and shows that informed short sellers prefer to trade in the opaque market.

## **2.6. Conclusion**

In this paper, we study how short sellers with different trading motivations behave when they could choose from parallel markets in different transparency regimes. We identify different short selling motivations, and show that short sellers with asymmetric information prefer the opaque market, short sellers with immediacy needs such as short-squeezed short sellers prefer the transparent market, and uninformed short sellers such as momentum and risk-bearing traders prefer the semi-transparent market.

We find that parallel markets complement each other in information revelation and liquidity provision. Our results provide the first real market evidence of investors' trading behaviour in parallel markets with different transparencies. Our findings also shed new light on the market design by illustrating that parallel markets in different transparency regimes can cater to investors' different trading needs. In future works, it would be interesting to examine the trading behaviour in the three parallel markets around corporate events, such as mergers and acquisitions, stock splits, seasoned equity offerings and earnings announcements. It is also worth examining the intraday trading patterns in the three parallel markets.

**Table 2.1 : Year and market distributions of short sales**

This table presents the year and market distribution for stocks that are short sold in the Taiwanese SBL market for the full sample as well as each parallel market. We report the statistics of stocks traded in each parallel market, and report the market share of each parallel market as a percentage of overall Taiwan SBL market based on that statistic. Our sample includes 1,045 common stocks that are listed on the TWSE or Gre Tai between January 2010 and December 2013. *Number of firms* is the total number of firms traded in each market each year. *Number of trades* is the total number of trades in each market each year, measured in thousands. *Lending fee* is the value-weighted lending fee of firms traded in each market each year, measured in percentage. *Total short volume* is the total number of shares traded in each market each year, measured in billions. *Total short value* is the total value of stocks traded in each market each year, measured in NT\$ billions. *Number of trades* and *lending fee* are only available for transparent and semi-transparent markets.

	Year	Full sample	Transparent market		Semi-transparent market		Opaque market	
			Number	Mkt share	Number	Mkt share	Number	Mkt share
<i>Number of firms</i>								
	2010	836	173		336		820	
	2011	935	198		557		904	
	2012	858	221		546		844	
	2013	855	243		627		819	
<i>Number of trades (thousands)</i>								
	2010		6.99		10.73			
	2011		9.72		15.68			
	2012		13.12		18.47			
	2013		15.57		19.70			
<i>Lending fee (%)</i>								
	2010		3.00		0.92			
	2011		3.06		1.17			
	2012		3.42		1.42			
	2013		2.45		1.31			
<i>Total short volume (billions)</i>								
	2010	17.08	5.02	29.38%	8.26	48.35%	3.80	22.27%
	2011	20.23	4.13	20.39%	11.23	55.50%	4.88	24.11%
	2012	18.27	3.31	18.14%	10.74	58.79%	4.22	23.07%
	2013	22.74	3.64	15.99%	14.87	65.41%	4.23	18.60%

**Table 2.1 (Cont'd)**

	Year	Full sample	Transparent market		Semi-transparent market		Opaque market	
		Number	Mkt share	Number	Mkt share	Number	Mkt share	
<i>Total short value (NT\$ billions)</i>								
	2010	1,041.74	361.85	34.74%	506.19	48.59%	173.70	16.67%
	2011	1,146.65	287.55	25.08%	626.20	54.61%	232.90	20.31%
	2012	1,009.20	283.48	28.09%	531.64	52.68%	194.08	19.23%
	2013	1,107.03	266.78	24.10%	685.87	61.96%	154.38	13.95%

**Table 2.2 : Summary statistics**

This table presents summary statistics for the full sample as well as each parallel market. Our sample includes 1,045 common stocks that are listed on the TWSE or Gre Tai between January 2010 and December 2013. *SHVOL* is the total lending volume measured in thousands. *SHRAT* is calculated as the ratio of daily lending volume to daily trading volume, measured in percentage. *Lending fee* is the annualized value-weighted lending fee of each trade, measured in percentage. *Amihud illiquidity* is measured as the ratio of absolute daily percentage return to daily dollar trading volume (Amihud, 2002). *B/M* is measured as the book value of equity divided by the market value of equity. *IO* is the percentage of the shares outstanding owned by institutional investors. *Capitalization* is the price per share times shares outstanding. *Turnover* is the total trading volume divided by shares outstanding, measured in percentage. *Intraday volatility* is the difference between daily high and low price, divided by the daily high price and measured in percentage. *Return volatility* is the standard deviation of daily stock returns over the previous month. .

Variables	(1) Full sample	(2) Transparent market	(3) Semi- transparent market	(4) Opaque market
<i>SHVOL (thousands)</i>				
Mean	63.72	13.47	41.41	13.02
Median	0.00	0.00	0.00	0.00
Std. Dev.	555.32	237.85	593.78	147.38
<i>SHRAT (%)</i>				
Mean	1.29	0.19	0.70	0.41
Median	0.00	0.00	0.00	0.00
Std. Dev.	9.09	3.64	6.98	4.04
<i>Lending fee (%)</i>				
Mean		2.97	1.24	
Median		2.50	0.01	
Std. Dev.		2.36	2.36	
<i>IO (%)</i>				
Mean	37.42	43.35	37.73	37.23
Median	35.41	43.70	35.88	35.36
Std. Dev.	21.41	21.65	21.30	21.27
<i>Capitalization (NT\$ billions)</i>				
Mean	13.73	34.94	20.19	13.72
Median	3.86	13.83	6.93	3.82
Std. Dev.	35.52	56.90	42.67	35.69
<i>Turnover (%)</i>				
Mean	0.66	0.71	0.67	0.66
Median	0.28	0.36	0.31	0.28
Std. Dev.	1.03	0.98	0.99	1.03
<i>Intraday volatility (%)</i>				
Mean	2.49	2.48	2.42	2.49
Median	2.13	2.15	2.07	2.13
Std. Dev.	1.68	2.15	1.60	1.68
<i>Return volatility (%)</i>				
Mean	2.00	2.01	1.94	2.00
Median	1.91	1.92	1.85	1.91
Std. Dev.	0.88	0.85	0.85	0.88

**Table 2.2 (Cont'd)**

Variables	(1) Full sample	(2) Transparent market	(3) Semi- transparent market	(4) Opaque market
<i>Amihud illiquidity (%)</i>				
Mean	0.41	0.09	0.14	0.41
Median	0.06	0.01	0.03	0.06
Std. Dev.	1.19	0.43	0.51	1.19
<i>B/M</i>				
Mean	0.88	0.79	0.82	0.88
Median	0.80	0.70	0.75	0.80
Std. Dev.	0.47	0.46	0.43	0.46

**Table 2.3 : Stock lending in parallel markets**

This table presents fixed-effect panel regression results for determinants of lending volume in the transparent, semi-transparent and opaque markets. The dependent variable is weekly *SHRAT* (measured in basis point) in the transparent market for Columns (1) and (2), semi-transparent market for Columns (3) and (4), opaque market for Columns (5) and (6). Independent variables include return, *winner*, *loser*, *intraday volatility*, *Amihud illiquidity*, *turnover*, *SHRAT* in the transparent, semi-transparent and opaque markets in the previous week, and contemporaneous *capitalization* and *IO*. Variables are as defined in previous tables. Our sample contains 323 common stocks that are listed on the TWSE or Gre Tai and have been traded in all three SBL markets from January 2010 to December 2013. All columns in this table include year dummy variables. Standard errors (reported in parentheses) are clustered by firm. \*\*\*, \*\* and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Variable	(1) Transparent market <i>SHRAT</i>	(2) Transparent market <i>SHRAT</i>	(3) Semi- Transparent market <i>SHRAT</i>	(4) Semi- Transparent market <i>SHRAT</i>	(5) Opaque market <i>SHRAT</i>	(6) Opaque market <i>SHRAT</i>
$R_{t-1}$	<b>0.18</b> (0.33)		<b>-3.00***</b> (0.63)		<b>-1.14***</b> (0.24)	
$Winner_{t-1}$		<b>10.30*</b> (6.01)		<b>5.60</b> (6.95)		<b>-6.27*</b> (3.54)
$Loser_{t-1}$		<b>7.37</b> (5.92)		<b>26.26**</b> (11.19)		<b>4.44</b> (4.44)
$Intraday\ volatility_{t-1}$	<b>-2.57</b> (2.34)	<b>-2.86</b> (2.37)	<b>8.10**</b> (3.72)	<b>9.77***</b> (3.67)	<b>-0.66</b> (1.75)	<b>0.06</b> (1.78)
$Amihud\ illiquidity_{t-1}$	<b>-0.06**</b> (0.03)	<b>-0.06**</b> (0.03)	<b>-0.05</b> (0.05)	<b>-0.05</b> (0.05)	<b>0.02</b> (0.11)	<b>0.02</b> (0.11)
$Turnover_{t-1}$	<b>-7.42**</b> (3.37)	<b>-7.54**</b> (3.30)	<b>-22.08***</b> (4.51)	<b>-29.23***</b> (4.34)	<b>-16.30***</b> (3.96)	<b>-18.62***</b> (3.90)
$Capitalization$	<b>-0.56</b> (0.35)	<b>-0.56</b> (0.35)	<b>0.00</b> (0.53)	<b>-0.03</b> (0.53)	<b>-0.55***</b> (0.15)	<b>-0.56***</b> (0.15)
$IO$	<b>-0.92*</b> (0.54)	<b>-0.95*</b> (0.55)	<b>-0.88</b> (0.71)	<b>-0.86</b> (0.71)	<b>-0.61</b> (0.42)	<b>-0.58</b> (0.42)
$Transparent\ market\ SHRAT_{t-1}$	<b>19.51***</b> (2.73)	<b>19.52***</b> (2.73)	<b>8.16***</b> (2.10)	<b>8.16***</b> (2.10)	<b>1.50**</b> (0.64)	<b>1.50**</b> (0.64)
$Semi-transparent\ market\ SHRAT_{t-1}$	<b>2.69***</b> (0.79)	<b>2.70***</b> (0.79)	<b>15.89***</b> (1.35)	<b>15.97***</b> (1.36)	<b>1.08***</b> (0.31)	<b>1.10***</b> (0.31)
$Opaque\ market\ SHRAT_{t-1}$	<b>5.55***</b> (1.81)	<b>5.57***</b> (1.81)	<b>11.60***</b> (1.95)	<b>11.89***</b> (1.97)	<b>19.68***</b> (1.28)	<b>19.76***</b> (1.27)
$Constant$	<b>144.08***</b> (28.64)	<b>143.67***</b> (28.56)	<b>244.01***</b> (36.13)	<b>240.49***</b> (35.91)	<b>142.00***</b> (19.99)	<b>141.23***</b> (19.90)
$Firm\ fixed\ effects$	Yes	Yes	Yes	Yes	Yes	Yes
$Number\ of\ observations$	44,205	44,205	44,205	44,205	44,205	44,205
$R^2\ (adjusted)$	0.05	0.05	0.05	0.05	0.05	0.05

**Table 2.4 : Portfolios based on recent lending**

This table reports the performance of portfolios sorted based on lending volume. Our sample contains 1,045 common stocks that are listed on the TWSE or Gre Tai between January 2010 and December 2013. Measures for lending volume include *SHVOL* and *SHRAT*. Performance measures include equally weighted raw return (*EWRT*) and equally-weighted abnormal return (*EWAR*). We report the portfolio performance with both a 5-day holding period and 20-day holding period. Panel A reports the full sample results. Panels B, C, and D reports sorting results of stocks traded in the transparent, semi-transparent, and opaque markets, respectively. The t-statistics (reported in parentheses) are estimated using Newey-West (1987) adjusted standard errors with 5 or 20 lags for a 5-day or 20-day holding period.

Panel A: Full sample

	5 days holding period				20 days holding period			
	EWRT (bps)	pf5-pf1 (bps)	EWAR (bps)	pf5-pf1 (bps)	EWRT (bps)	pf5-pf1 (bps)	EWAR (bps)	pt5-pf1 (bps)
Portfolios sorted by <i>SHVOL</i>								
1 (least)	-1.79		-0.98		-0.49		-18.26	
2	-1.85		-4.18		-0.70		-25.41	
3	-5.54		-9.89		-0.42		-31.46	
4	-14.48	-15.20	-18.05	-21.15	-0.94	-13.38	-43.68	-42.40
5 (most)	-17.19	(-2.05)	-22.07	(-3.32)	-1.26	(-0.51)	-57.95	(-2.02)
Portfolios sorted by <i>SHRAT</i>								
1 (least)	-2.77		-4.48		-54.88		-39.18	
2	-7.03		-9.36		-52.88		-34.57	
3	-6.95		-9.95		-55.28		-40.37	
4	-10.21	-12.20	-12.85	-14.30	-38.94	-9.16	-27.79	-14.06
5 (most)	-14.94	(-1.78)	-18.80	(-2.19)	-64.04	(-0.40)	-53.24	(-0.65)

Panel B: Transparent market

	5 days holding period				20 days holding period			
	EWRT (bps)	pf5-pf1 (bps)	EWAR (bps)	pf5-pf1 (bps)	EWRT (bps)	pf5-pf1 (bps)	EWAR (bps)	pf5-pf1 (bps)
Portfolios sorted by <i>SHVOL</i>								
1 (least)	-9.35		-13.55		-36.57		-32.68	
2	-17.22		-21.13		-29.00		-28.14	
3	-21.70		-24.99		-67.26		-66.18	
4	-24.03	-5.20	-27.68	-5.65	-80.23	-42.20	-77.26	-45.20
5 (most)	-14.53	(-0.36)	-19.18	(-0.40)	-78.76	(-0.96)	-77.84	(-1.05)
Portfolios sorted by <i>SHRAT</i>								
1 (least)	-11.91		-19.19		-27.52		-34.41	
2	-6.76		-10.53		-35.13		-35.28	
3	-26.14		-28.64		-87.78		-82.99	
4	-29.34	-0.22	-32.73	4.15	-72.16	-41.60	-69.44	-26.00
5 (most)	-12.13	(-0.02)	-15.05	(0.30)	-69.03	(-1.22)	-60.49	(-0.76)



**Table 2.4 (Cont'd)**

## Panel C: Semi-transparent market

	5 days holding period				20 days holding period			
	EWRT (bps)	pf5-pf1 (bps)	EWAR (bps)	pf5-pf1 (bps)	EWRT (bps)	pf5-pf1 (bps)	EWAR (bps)	pf5-pf1 (bps)
Portfolios sorted by <i>SHVOL</i>								
1 (least)	-7.49		-9.61		-36.92		-25.60	
2	-6.38		-7.90		-44.12		-32.64	
3	-12.47		-16.28		-39.75		-36.39	
4	-8.04	-2.68	-11.96	-5.70	-22.86	-16.74	-20.13	-32.00
5 (most)	-10.17	(-0.28)	-15.33	(-0.62)	-53.66	(-0.56)	-57.58	(-1.15)
Portfolios sorted by <i>SHRAT</i>								
1 (least)	-5.68		-10.20		-35.17		-33.74	
2	-12.07		-16.13		-44.98		-40.38	
3	-9.51		-12.22		-49.04		-42.22	
4	-4.60	-7.10	-7.54	-4.99	-27.65	-3.86	-23.51	2.54
5 (most)	-12.76	(-0.70)	-15.19	(-0.51)	-39.03	(-0.14)	-31.21	(0.09)

## Panel D: Opaque market

	5 days holding period				20 days holding period			
	EWRT (bps)	pf5-pf1 (bps)	EWAR (bps)	pf5-pf1 (bps)	EWRT (bps)	pf5-pf1 (bps)	EWAR (bps)	pf5-pf1 (bps)
Portfolios sorted by <i>SHVOL</i>								
1 (least)	-1.29		2.47		-15.53		-0.32	
2	-7.51		-5.16		-26.64		-0.88	
3	-11.14		-11.92		-47.82		-2.26	
4	-14.12	-27.65	-15.96	-33.70	-34.53	-62.40	-1.92	-86.00
5 (most)	-30.71	(-3.28)	-32.40	(-4.31)	-84.48	(-1.98)	-4.76	(-3.07)
Portfolios sorted by <i>SHRAT</i>								
1 (least)	-3.88		-6.91		-46.74		-35.25	
2	0.33		-0.65		-38.65		-20.89	
3	-10.00		-12.71		-56.02		-38.10	
4	-15.34	-13.00	-17.61	-14.05	-76.52	-46.40	-58.23	-43.40
5 (most)	-16.89	(-1.68)	-20.94	(-1.95)	-93.15	(-1.80)	-78.67	(-1.84)

**Table 2.5 : Return predictive power by stock lending in three markets**

This table presents weekly Fama and MacBeth (1973) regression results of stock returns. The dependent variable is return in the Panel A and *risk-adjusted AR*, which is measured as the difference between stock return and the return of a corresponding Fama-French 25 size/book-to-market portfolio in Panel B. Independent variables include *SHRAT* (measured in percentage) in the transparent, semi-transparent and opaque markets, *three markets* which is a dummy variable that equals one if the stock has positive lending volume in all three markets during the week, and zero otherwise, *lending fee* in the transparent and semi-transparent markets, *winner*, *loser*, *Return volatility*, *Amihud illiquidity*, *turnover*, *capitalization* and *B/M*. Variables are as defined in Table 2. Our sample contains 323 common stocks that are listed on the TWSE or Gre Tai and have been traded in all three SBL markets from January 2010 to December 2013. All columns in this table include year dummy variables. Standard errors (reported in parentheses) are adjusted for auto-correlation using the Newey and West (1987) method with 6 lags. \*\*\*, \*\* and \* indicate significance at the 1%, 5%, and 10% levels, respectively. Our sample consist 323 stocks that are traded in three SBL markets from January 2010 to December 2013.

Panel A: Dependent variable is raw return

Variable	(1) R <sub>t+1</sub>	(2) R <sub>t+1</sub>	(3) R <sub>t+2</sub>	(4) R <sub>t+2</sub>	(5) R <sub>t+4</sub>	(6) R <sub>t+4</sub>
<i>Transparent market SHRAT</i>	<b>-0.90</b> (0.77)	<b>-0.91</b> (0.72)	<b>-1.82</b> (1.28)	<b>-2.15*</b> (1.28)	<b>-3.23*</b> (1.79)	<b>-3.88**</b> (1.67)
<i>Semi-transparent market SHRAT</i>	<b>-0.37</b> (0.41)	<b>0.72</b> (0.65)	<b>-0.66</b> (0.86)	<b>0.59</b> (1.07)	<b>-0.98</b> (1.29)	<b>0.39</b> (1.48)
<i>Opaque market SHRAT</i>	<b>-6.74***</b> (1.48)	<b>-5.30***</b> (1.56)	<b>-12.63***</b> (2.42)	<b>-7.21***</b> (2.29)	<b>-18.87***</b> (4.16)	<b>-7.45*</b> (3.84)
<i>Three markets</i>		<b>-4.48</b> (21.92)		<b>34.32</b> (37.95)		<b>-23.13</b> (51.61)
<i>Transparent market lending fee</i>		<b>-3.75*</b> (1.90)		<b>-9.80***</b> (3.63)		<b>-19.78***</b> (7.14)
<i>Semi-transparent market lending fee</i>		<b>-0.79</b> (1.47)		<b>1.36</b> (2.70)		<b>1.38</b> (4.34)
<i>Winner</i>		<b>-9.76</b> (13.30)		<b>-0.58</b> (18.90)		<b>12.42</b> (22.61)
<i>Loser</i>		<b>27.10***</b> (9.51)		<b>28.55*</b> (15.47)		<b>41.41**</b> (18.92)
<i>Return volatility</i>		<b>-2.14</b> (4.93)		<b>-4.04</b> (9.25)		<b>-7.23</b> (17.13)
<i>Amihud illiquidity</i>		<b>1.87</b> (3.62)		<b>6.91</b> (6.47)		<b>12.47</b> (9.65)
<i>B/M</i>		<b>-51.27***</b> (11.78)		<b>-100.95***</b> (23.59)		<b>-207.68***</b> (45.81)
<i>Capitalization</i>		<b>-0.07</b> (0.06)		<b>-0.13</b> (0.11)		<b>-0.29</b> (0.20)
<i>Turnover</i>		<b>-2.13</b> (7.94)		<b>-1.35</b> (13.76)		<b>-13.56</b> (23.95)
<i>Constant</i>	<b>12.27</b> (18.54)	<b>61.48**</b> (24.26)	<b>24.39</b> (35.49)	<b>120.70**</b> (46.65)	<b>49.59</b> (66.38)	<b>259.15***</b> (89.43)
Number of observations	44,619	25,194	44,835	25,194	44,835	25,194
R <sup>2</sup> (average)	0.02	0.17	0.02	0.17	0.02	0.19

**Table 2.5 (Cont'd)**

Panel B: Dependent variable is risk-adjusted abnormal return

Variable	(1) Risk- adjusted AR <sub>t+1</sub>	(2) Risk- adjusted AR <sub>t+1</sub>	(3) Risk- adjusted AR <sub>t+2</sub>	(4) Risk- adjusted AR <sub>t+2</sub>	(5) Risk- adjusted AR <sub>t+4</sub>	(6) Risk- adjusted AR <sub>t+4</sub>
<i>Transparent market SHRAT</i>	<b>-0.63</b> (0.68)	<b>-0.66</b> (0.71)	<b>-2.12</b> (1.49)	<b>-1.82</b> (1.77)	<b>-3.26*</b> (1.94)	<b>-3.14</b> (2.12)
<i>Semi-transparent market SHRAT</i>	<b>-0.12</b> (0.40)	<b>0.80</b> (0.61)	<b>-1.56</b> (1.15)	<b>-0.61</b> (1.21)	<b>-1.82</b> (1.52)	<b>-0.70</b> (1.65)
<i>Opaque market SHRAT</i>	<b>-6.51***</b> (1.37)	<b>-4.88***</b> (1.46)	<b>-21.19***</b> (2.74)	<b>-17.80***</b> (2.94)	<b>-27.19***</b> (4.21)	<b>-17.91***</b> (4.21)
<i>Three channels</i>		<b>-7.64</b> (22.11)		<b>-17.41</b> (55.37)		<b>-72.61</b> (63.48)
<i>Transparent market lending fee</i>		<b>-3.40*</b> (1.87)		<b>-15.51***</b> (4.80)		<b>-24.71***</b> (8.00)
<i>Semi-transparent market lending fee</i>		<b>0.06</b> (1.56)		<b>1.56</b> (3.32)		<b>3.06</b> (4.97)
<i>Winner</i>		<b>-13.68</b> (12.86)		<b>-31.61</b> (21.36)		<b>-22.42</b> (25.25)
<i>Loser</i>		<b>26.55***</b> (9.44)		<b>70.34***</b> (21.82)		<b>84.84***</b> (24.98)
<i>Return volatility</i>		<b>-1.56</b> (5.06)		<b>-24.25*</b> (12.99)		<b>-26.95</b> (20.33)
<i>Amihud illiquidity</i>		<b>2.09</b> (3.48)		<b>13.03*</b> (7.65)		<b>19.07*</b> (10.12)
<i>B/M</i>		<b>-72.04***</b> (11.29)		<b>-177.20***</b> (29.87)		<b>-323.54***</b> (50.65)
<i>Capitalization</i>		<b>-0.07</b> (0.06)		<b>0.13</b> (0.14)		<b>-0.05</b> (0.22)
<i>Turnover</i>		<b>-2.95</b> (8.01)		<b>76.63***</b> (19.04)		<b>60.77**</b> (28.77)
<i>Constant</i>	<b>3.66</b> (2.53)	<b>70.10**</b> (30.97)	<b>16.24**</b> (7.62)	<b>210.50**</b> (82.12)	<b>20.63*</b> (12.44)	<b>363.97***</b> (134.10)
<i>Number of observations</i>	44,619	25,194	44,835	25,194	44,835	25,194
<i>R<sup>2</sup> (average)</i>	0.02	0.16	0.02	0.19	0.02	0.20

**Table 2.6 : Liquidity provision by stock lending in parallel markets**

This table presents weekly fixed-effect panel regression results for the liquidity provision by transparent, semi-transparent and opaque markets. The dependent variable is *Amihud illiquidity*. Independent variables include *SHRAT* (measured in percentage) in the transparent, semi-transparent and opaque markets, *three markets* which is a dummy variable that equals one if the stock has positive lending volume in all three markets during the week, and zero otherwise, return, *winner*, *loser*, *Return volatility*, *Amihud illiquidity* and *turnover* in the previous week, and contemporaneous *capitalization* and *IO*. Variables are as defined in Table 2. Our sample contains 323 common stocks that are listed on the TWSE or Gre Tai and have been traded in all three SBL markets from January 2010 to December 2013. All columns in this table include year dummy variables. Standard errors (reported in parentheses) are clustered by firm. \*\*\*, \*\* and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Variable	(1) Amihud illiquidity	(2) Amihud illiquidity	(3) Amihud illiquidity	(4) Amihud illiquidity	(5) Amihud illiquidity	(6) Amihud illiquidity	(7) Amihud illiquidity	(8) Amihud illiquidity
<i>Transparent market SHRAT<sub>t-1</sub></i>	<b>-0.02***</b> (0.01)	<b>-0.02***</b> (0.01)					<b>-0.01**</b> (0.01)	<b>-0.01**</b> (0.01)
<i>Semi-transparent market SHRAT<sub>t-1</sub></i>			<b>-0.00</b> (0.01)	<b>-0.01</b> (0.01)			<b>-0.00</b> (0.01)	<b>-0.00</b> (0.01)
<i>Opaque market SHRAT<sub>t-1</sub></i>					<b>-0.08***</b> (0.02)	<b>-0.08***</b> (0.03)	<b>-0.07***</b> (0.02)	<b>-0.08***</b> (0.03)
<i>Three markets<sub>t-1</sub></i>	<b>-0.18</b> (0.14)	<b>-0.21</b> (0.15)	<b>-0.23</b> (0.15)	<b>-0.26*</b> (0.15)	<b>-0.07</b> (0.13)	<b>-0.09</b> (0.14)	<b>-0.03</b> (0.13)	<b>-0.05</b> (0.13)
<i>R<sub>t-1</sub></i>	<b>0.03</b> (0.03)		<b>0.03</b> (0.03)		<b>0.03</b> (0.03)		<b>0.03</b> (0.03)	
<i>Winner<sub>t-1</sub></i>		<b>-0.34</b> (0.26)		<b>-0.34</b> (0.26)		<b>-0.35</b> (0.26)		<b>-0.35</b> (0.26)
<i>Loser<sub>t-1</sub></i>		<b>-0.06</b> (0.32)		<b>-0.06</b> (0.32)		<b>-0.07</b> (0.32)		<b>-0.07</b> (0.33)
<i>Return volatility<sub>t-1</sub></i>	<b>-0.16</b> (0.17)	<b>-0.15</b> (0.17)	<b>-0.16</b> (0.17)	<b>-0.15</b> (0.17)	<b>-0.16</b> (0.17)	<b>-0.15</b> (0.17)	<b>-0.16</b> (0.17)	<b>-0.15</b> (0.17)
<i>Turnover<sub>t-1</sub></i>	<b>-1.54***</b> (0.22)	<b>-1.49***</b> (0.21)	<b>-1.54***</b> (0.22)	<b>-1.48***</b> (0.22)	<b>-1.55***</b> (0.22)	<b>-1.50***</b> (0.21)	<b>-1.55***</b> (0.22)	<b>-1.50***</b> (0.22)
<i>IO</i>	<b>0.00</b> (0.02)	<b>0.00</b> (0.02)	<b>0.00</b> (0.02)	<b>0.00</b> (0.02)	<b>0.00</b> (0.02)	<b>0.00</b> (0.02)	<b>0.00</b> (0.02)	<b>0.00</b> (0.02)

**Table 2.6 (Cont'd)**

<i>Capitalization</i>	<b>-0.02***</b>	<b>-0.02***</b>	<b>-0.02***</b>	<b>-0.02**</b>	<b>-0.02***</b>	<b>-0.02***</b>	<b>-0.02***</b>	<b>-0.02***</b>
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
<i>Amihud illiquidity<sub>t-1</sub></i>	<b>0.06*</b>	<b>0.06*</b>	<b>0.06*</b>	<b>0.06*</b>	<b>0.06*</b>	<b>0.06*</b>	<b>0.06*</b>	<b>0.06*</b>
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
<i>Constant</i>	<b>8.37***</b>	<b>8.37***</b>	<b>8.35***</b>	<b>8.35***</b>	<b>8.48***</b>	<b>8.49***</b>	<b>8.50***</b>	<b>8.51***</b>
	(1.19)	(1.20)	(1.18)	(1.19)	(1.19)	(1.20)	(1.19)	(1.19)
<i>Firm fixed effects</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Number of observations</i>	44,205	44,205	44,205	44,205	44,205	44,205	44,205	44,205
<i>R<sup>2</sup> (adjusted)</i>	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

**Table 2.7 : Robustness tests– return differences on short sale portfolios for stocks traded in three markets**

This table reports the return differences of portfolios sorted based on lending volume. Our sample contains 323 common stocks that are listed on the TWSE or Gre Tai and have been traded in all three SBL markets from January 2010 to December 2013. Measures for lending volume include *SHVOL* and *SHRAT*. Performance measures include equally weighted raw return (*EWRT*) and equally-weighted abnormal return (*EWAR*). We report the portfolio performance differences with both a 5-day holding period and 20-day holding period. Panel A reports the full sample results. Panels B, C, and D reports sorting results of stocks traded in the transparent, semi-transparent, and opaque markets, respectively. The t-statistics (reported in parentheses) are estimated using Newey-West (1987) adjusted standard errors with 5 or 20 lags for a 5-day or 20-day holding period.

Panel A: All Markets

	5 days holding period		20 days holding period	
	EWRT (bps)	EWAR (bps)	EWRT (bps)	EWAR (bps)
Portfolios sorted by Lending SHVOL				
ptf5-ptf1	-19.30	-22.50	-37.00	-57.20
t-stat	(-2.17)	(-2.79)	(-1.24)	(-2.09)
Portfolios sorted by SHRAT				
ptf5-ptf1	-26.05	-24.70	-43.20	-43.40
t-stat	(-3.29)	(-3.24)	(-1.65)	(-1.67)

Panel B: Transparent Market

	5 days holding period		20 days holding period	
	EWRT (bps)	EWAR (bps)	EWRT (bps)	EWAR (bps)
Portfolios sorted by Lending SHVOL				
ptf5-ptf1	-3.29	-3.34	-40.80	-42.20
t-stat	(-0.22)	(-0.23)	(-0.91)	(-0.95)
Portfolios sorted by SHRAT				
ptf5-ptf1	0.27	4.74	-40.60	-25.20
t-stat	(0.02)	(0.33)	(-1.11)	(-0.68)

Panel C: Semi-transparent Market

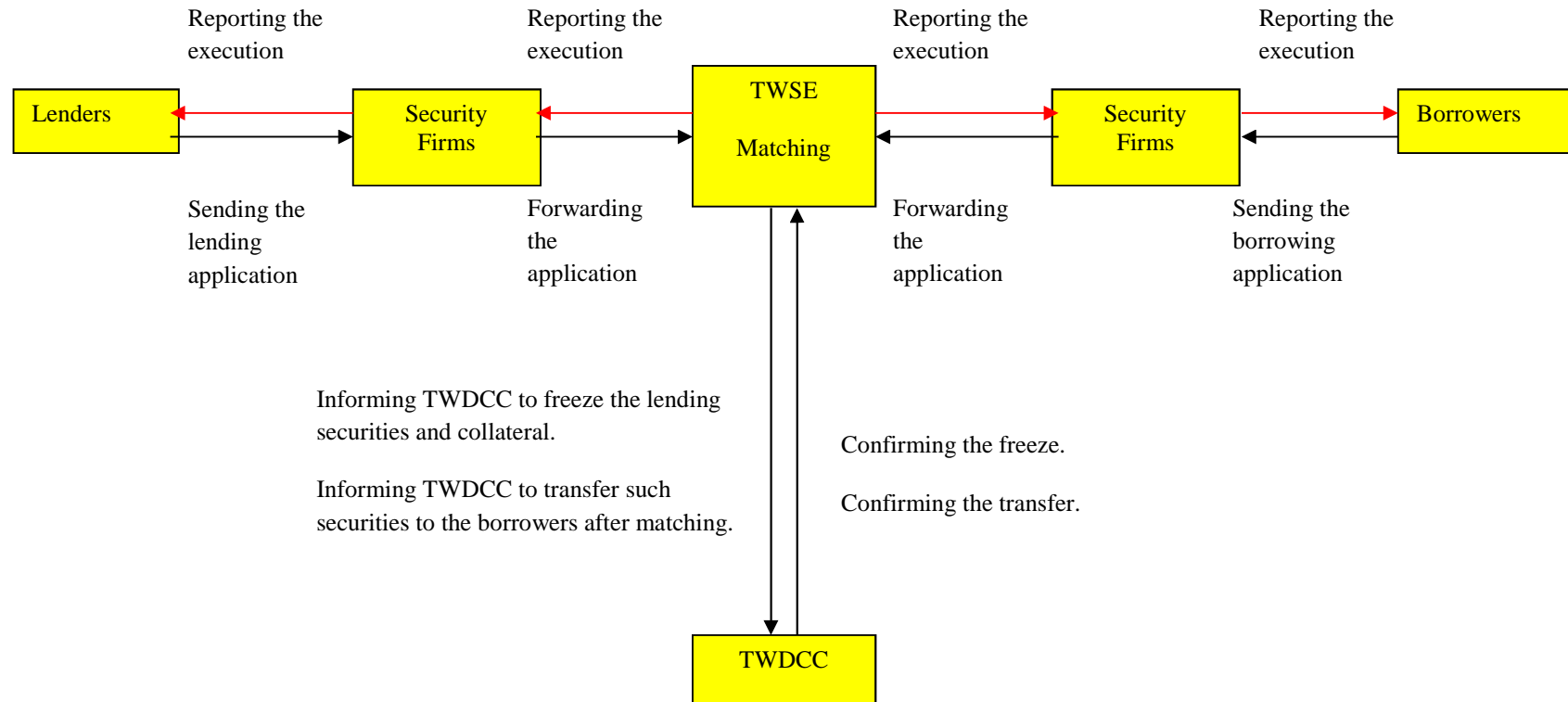
	5 days holding period		20 days holding period	
	EWRT (bps)	EWAR (bps)	EWRT (bps)	EWAR (bps)
Portfolios sorted by Lending SHVOL				
ptf5-ptf1	-2.79	-5.80	-21.80	-35.00
t-stat	(-0.28)	(-0.60)	(-0.63)	(-1.06)
Portfolios sorted by SHRAT				
ptf5-ptf1	-7.10	-4.61	-4.42	0.77
t-stat	(-0.67)	(-0.45)	(-0.15)	(0.03)

Panel D: Opaque Market

	5 days holding period		20 days holding period	
	EWRT (bps)	EWAR (bps)	EWRT (bps)	EWAR (bps)
Portfolios sorted by Lending SHVOL				
ptf5-ptf1	-36.25	-39.05	-106.80	-123.80
t-stat	(-3.27)	(-3.80)	(-2.54)	(-3.18)
Portfolios sorted by SHRAT				
ptf5-ptf1	-39.40	-36.90	-106.00	-100.60
t-stat	(-4.22)	(-4.08)	(-3.09)	(-3.04)

**Figure 2.1 : The trading process for transparent market transactions**

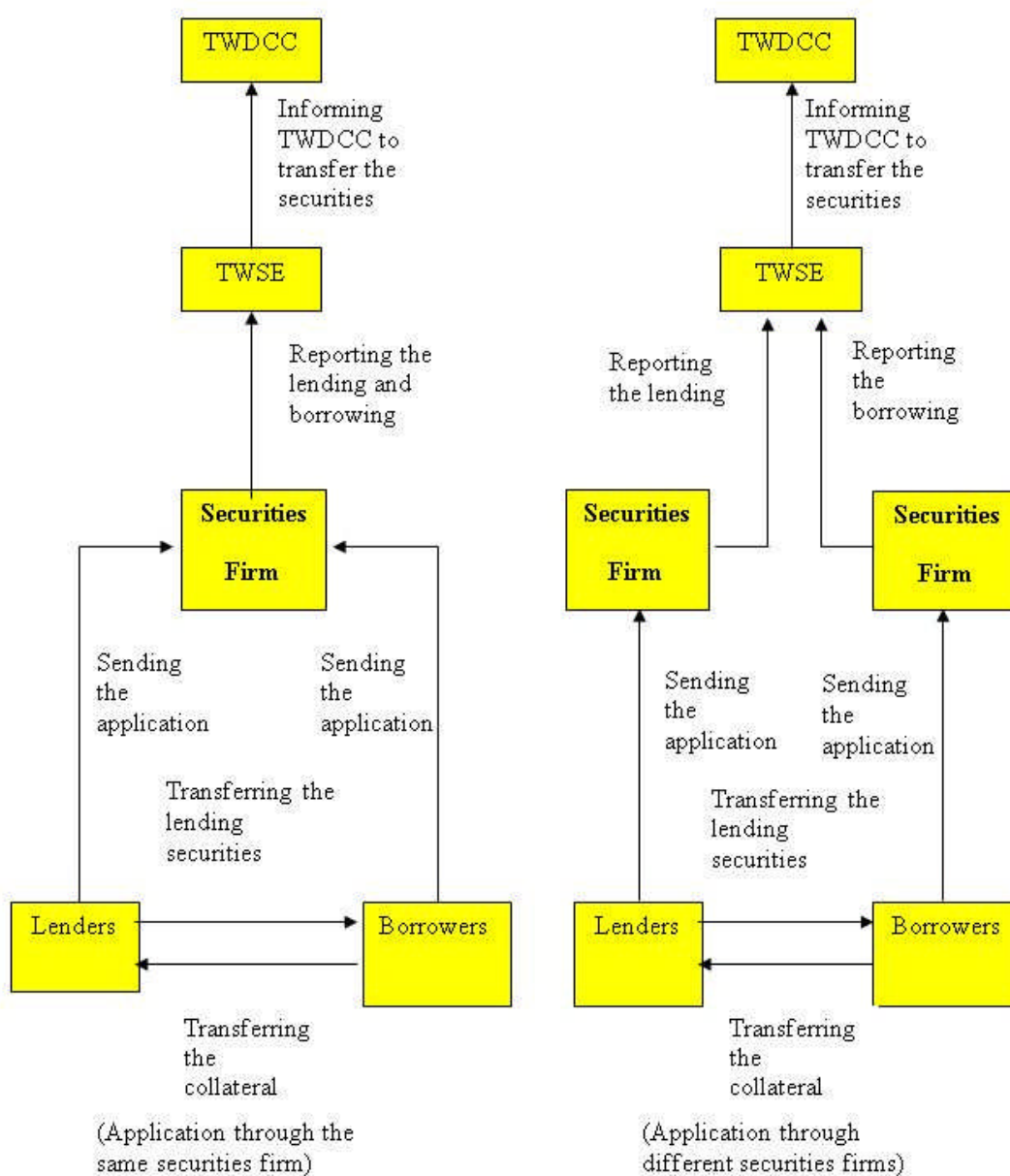
This figure shows the trading process for the transparent market transactions in Taiwan.



Source: the TWSE website

**Figure 2.2 : The trading process for semi-transparent market transactions**

This figure shows the trading process for the semi-transparent market transactions in Taiwan.

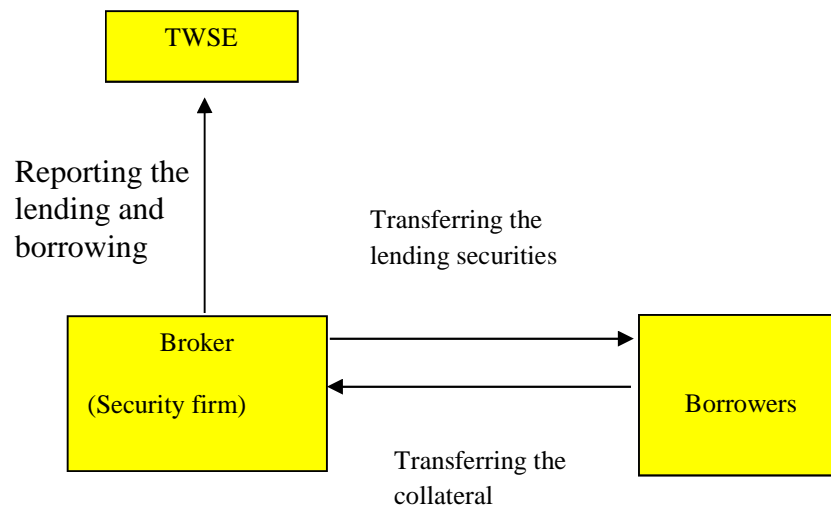


Source: the TWSE website



**Figure 2.3 : The trading process for opaque market transactions**

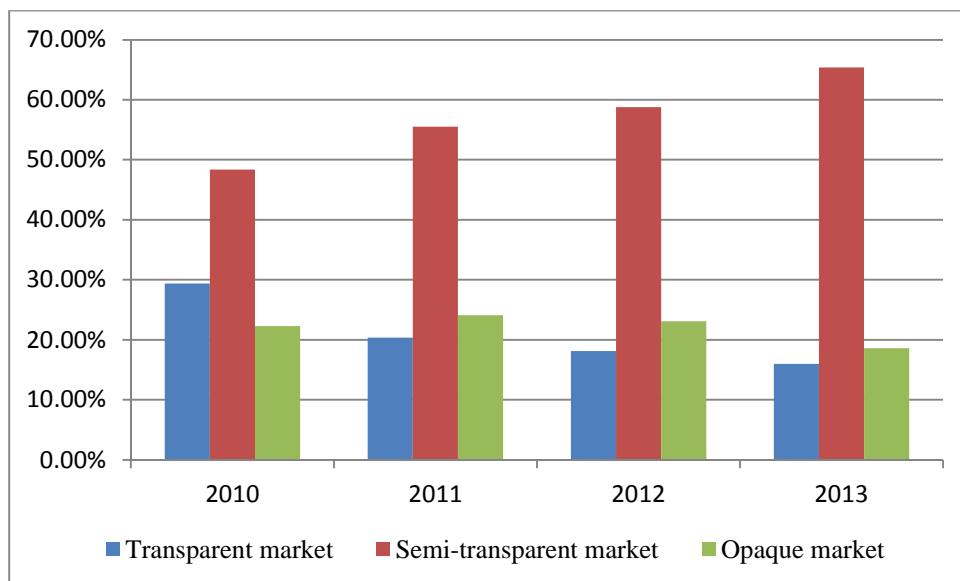
This figure shows the trading process for the opaque market transactions in Taiwan.



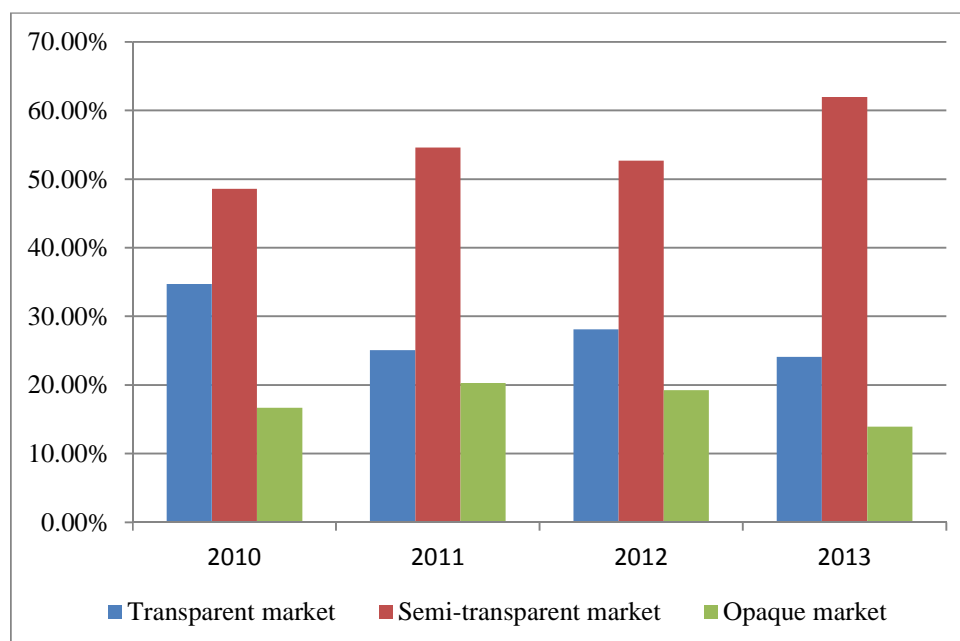
**Figure 2.4 : Market share of parallel markets**

This figure plots the market share of each SBL market as a percentage of overall Taiwan SBL business. Panel A plots the market share of total SBL volume in parallel markets, which is calculated as total volume of short sales in the market divided by total short sale volume in the Taiwanese SBL market, for the transparent, semi-transparent and opaque markets during the January 2008 to December 2010 period. Panel B plots the market share of total SBL value in parallel markets, which is calculated as the total value of short sales in the market divided by total short sale value in the Taiwanese SBL market, for the transparent, semi-transparent and opaque markets during the January 2008 to December 2010 period.

Panel A: Market share of total SBL volume in parallel markets

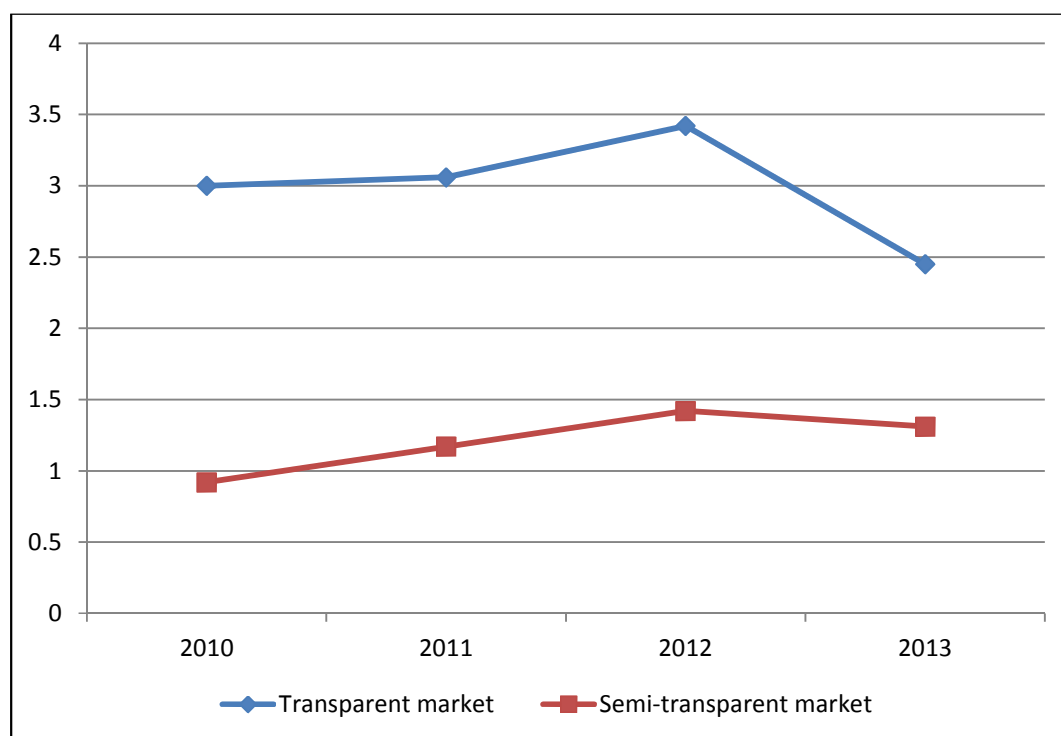


Panel B: Market share of total SBL value in parallel markets



**Figure 2.5 : Lending fees in transparent and semi-transparent markets**

This figure plots the annualized lending fee measured in basis points in the transparent and semi-transparent markets during the January 2008 to December 2010 period.



## **Chapter 3**

### **Short Selling Before Initial Public Offerings**

#### **3.1. Introduction**

In this paper we analyze the effect of relaxing short-sale constraints on the market performance of initial public offerings (IPOs). We show that the presence of short sellers before an IPO reduces first-day IPO return and improves long-run stock performance. The average first-day IPO return has been abnormally high in the past five decades (Ibbotson, Sindelar, and Ritter 1994), which is often referred as the IPO underpricing puzzle. IPOs with higher first-day price run-up are associated with lower return in the long-run (Ritter, 1991; Loughran and Ritter, 1995). Theories predict that short-sale constraints and opinion dispersion could lead to the market overvaluation of IPOs in the short-term (Miller, 1977; Derrien, 2005; and Ljungqvist, Nanda, and Singh, 2006). This overpricing would revert back to the fundamental value in the long-run with the gradual relaxation of short-sale constraints. However, since the short-sale supply of stocks does not typically exist before the offering date of an IPO, the effects of short-sale constraints on IPO related issues have not been directly examined.

In this study, we examine how the relaxation of short-sale constraints before the IPO offering day affects the IPO first-day return and subsequent long-run performance. If short-sale constraints reduce the pricing efficiency of IPOs, the presence of stock lending supply would reduce the initial abnormal returns on the public offering day. Further, with the gradual relaxation of short-sale constraints, short sellers could arbitrage away the initial overpricing in the long-run, which leads to poor long-run performance after IPOs. Therefore, if short-sale supply is available before the public offering day, IPOs should experience lower initial return and better

long-run performance. Specifically, we posit that the existence of short-sale supply before the IPO offering day are likely to (i) reduce the first-day IPO return and (ii) improve the long-run performance.

To test these conjectures, we obtain a novel sample from the London Stock Exchange (LSE) on which firms could go public via a two-stage IPO strategy (i.e., *introduction*). An introduction, which has the same regulatory requirements as a conventional one-stage IPO, allows issuers to separate the listing (i.e., the first-stage introduction) and equity issuance (i.e., the second-stage offering) into two stages, while in the first-stage introduction, firms are listed on the LSE without raising new capital. In the second-stage offering, listed firms raise capital by issuing new shares. Importantly, existing shares could be borrowed and sold short immediately after the first-stage introduction. When there exists a stock lending supply after the first-stage introduction, the second-stage equity issuance becomes short-sale unconstrained. Short sellers would short existing shares before the second-stage offering day if they believed stocks are overpriced, which in turn would reduce the upward price pressure on the second-stage offering day. Consequently, among two-stage IPO firms, firms with higher security lending supply are expected to have less price run-up on the second-stage offering day and better performance in the long-run.

We start by examining whether relaxing short-sale constraints before IPOs reduces the initial return on the public offering day. Consistent with our conjecture, we find that two-stage IPO firms with higher security lending supply before the second-stage offering day experience lower initial price run-up. This evidence is also consistent with Diamond and Verrecchia (1987) who show that short-sale constraints could reduce the adjustment speed of price to negative information.

In addition, the existing literature suggests that underwriters would intentionally underprice IPOs, which in turn could generate higher initial return (Rock, 1986; Benveniste and Spindt, 1989). However, we find that the effects of short-sale constraints on the first-day IPO return could not be explained by the pricing discount offered by underwriters.

Next, we examine the effects of short-sale constraints on IPO long-run performance. Consistent with our expectation, we find a positive relation between the level of lending supply before the second-stage offering and the subsequent long-run stock performance. This evidence supports Miller (1977), who conjectures that short-sale constraints on the IPO offering day could contribute to the subsequent long-run underperformance. Our findings are also in line with Derrien (2005), Cornelli, Goldreich, and Ljungqvist (2006), and Dorn (2009) who show that the overvaluation of IPOs in the short-run could be associated with subsequent underperformance in the long-run.

Our findings contribute to three different strands of finance literature. First, to the best of our knowledge, this is the first paper that examines short selling before IPOs.<sup>7</sup> Theoretical studies predict that short-sale constraints and opinion dispersion on the IPO offering day could be associated with the initial price run-up and subsequent long-run underperformance (e.g., Miller, 1977). However, in conventional IPOs, short-sale supply is unobservable since data on stock lending supply are only available for publicly listed stocks.<sup>8</sup> Edwards and Hanley (2010)

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<sup>7</sup> There are some papers that examine the pre-IPO (i.e., grey) market (e.g., Dorn, 2009; Aussenegg, Pichler and Stomper, 2006; and Cornelli, Goldreich, and Ljungqvist, 2006). However, in the grey market, security lending supply does not exist and retail investors are restricted from selling short (Dorn, 2009). Therefore, existing studies on grey market still assume that short-sale constraints exist in the grey market as well as the early IPO aftermarket.

<sup>8</sup> Previous studies mainly focus on testing the effects of opinion dispersion on IPO related puzzles and simply take and support the assumption of short-sale constraints in the IPO aftermarket (Geczy,

challenge this assumption by looking at the IPO first-day short interest. They find that short-sale is prevalent on the offering day and is positively correlated with first day return. However, determined by both short-sale supply and demand, short interest does not directly measure short-sale constraints. Using a novel sample with pre-IPO short-sale supply data, we directly test the effects of short-sale constraints and find supporting evidence.

Second, we show that relaxing short-sale constraints improves pricing efficiency (e.g., Boehmer, Jones, and Zhang, 2008; Saffi and Sigurdsson, 2010; Boehmer and Wu, 2013) in a new economic setting. Existing short selling literature mainly focuses on the effects of short-selling bans to examine this relation (e.g., Autore, Billingsley and Kovacs, 2011; Beber and Pagano, 2013). We provide new evidence to support this prediction from the IPO market.

Third, we add to the literature on the benefits of the two-stage IPO strategy and provide a new motivation behind this strategy. Derrien and Kecskés (2007) show that a two-stage IPO strategy is more effective and efficient than a conventional IPO. We further show that a two-stage IPO strategy would reduce short-run overpricing and improve the long-run performance of the newly listed firm, since short-sale constraints could be relaxed. These benefits would be valuable for practitioners and market designers.

The rest of our paper proceeds as follows: Section 2 describes the institutional features of the two-stage IPO strategy. In Section 3, we develop our hypotheses. Section 4 describes our sample selection process and summary statistics. Section 5 presents our methods and empirical results. Section 6 concludes.

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Musto, and Reed , 2002; Ofek and Richardson, 2003; and Houge, Loughran, Suchanek, and Yan , 2001). Their empirical opinion dispersion measures have significant explanatory power for both the short-term IPO overpricing and subsequent long-term underperformance.

### 3.2. Institutional features of a two-stage IPO

At the London Stock Exchange, issuers could choose to go public through a conventional IPO process or via an *introduction*. For a conventional IPO, issuers become listed and raise capital simultaneously. The nominated broker would be responsible for pricing and promoting the newly issued shares. Meanwhile, for an *introduction*, issuers are listed without raising capital in the first-stage introduction. Current shareholders could trade with investors who wish to buy the existing shares, but no new shares are issued at this stage. Further, with a first-stage introduction, issuers could gain access to more institutional investors by increasing their visibility.

After the first-stage introduction, many firms continue with a second-stage offering to raise new capital. The regulatory requirements for the second-stage offering are minimal. In particular, issuers only need to file a prospectus containing updated introduction prospectus, previously disclosed information and terms of the current offering if the additional offering is sold to a large number of investors. Therefore, firms with a two-stage IPO strategy could time the market more effectively than those with a conventional IPO. Following Derrien and Kecskés (2007), we define firms that get listed through a first-stage introduction and complete their second-stage offering within five years as two-stage IPO firms.

The two-stage IPO strategy provides an ideal setting to investigate the effect of short-sale constraints on IPO-related issues. This strategy is highly comparable to a conventional IPO but substantially different from a seasoned equity offering (SEO).<sup>9</sup> Further, for two-stage IPO firms, the market developed for existing shares at the

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<sup>9</sup> The main difference between the second-stage offering and a SEO is whether the firm has conducted public issuance before. Further, Derrien and Kecskés (2007) find that the offering time, market reaction, offering day trading volume, and price run-up before the second-stage offering for two-stage firms are highly comparable to conventional IPOs, but significantly different from SEOs.



first-stage introduction also helps to reduce the uncertainty for the second-stage new issuance (Derrien and Kecskés, 2007).

### **3.3. Hypotheses development**

Our first hypothesis focuses on the effects of short sale constraints on the first-day IPO return. The positive abnormal return on the first trading day following an IPO has attracted interests among scholars over the past decades (e.g., Ibbotson, 1975; Beatty and Ritter, 1986; and Loughran and Ritter, 2004). However, the reason for “money on the table” remains inconclusive. Among others, Allen and Faulhaber (1989), Grinblatt and Hwang (1989), and Welch (1989) predict that due to information asymmetry, high-quality firms distinguish themselves from low quality firms by underpricing initial public offerings. In addition, Rock (1986) presents a model with two groups of investors: informed investors who would only buy new issuance when shares are underpriced, and uninformed investors who could not distinguish between underpriced and overpriced new issuance. He shows that uninformed investors would not purchase new issuance because they would be allocated with only a portion of the underpriced new issuance, but “win” the entire overpriced new issuance (i.e., “the winner’s curse”). Therefore, issuers need to deliberately underprice offerings to attract uninformed investors and ensure full allocation. Miller (1977) and Ljungqvist, Nanda, and Singh (2006) suggest that heterogeneous beliefs and short sale constraints could help to explain the large first-day IPO return, because pessimistic investors could not short sell shares in the early IPO after-market.

Further, the short selling literature shows that short sale constraints could lead to pricing inefficiency. For example, Autore, Billingsley and Kovacs (2011), Marsh and

Payne (2012), and Beber and Pagano (2013) show that the 2008 short selling ban reduces the stock pricing efficiency. Similarly, Saffi and Sigurdsson (2010) find that stocks with limited lending supply experience lower pricing efficiency.

Therefore, if the large IPO initial return is caused by short sale constraints, the existence of short sale supply before the public offering day should improve the pricing efficiency and reduce the IPO initial return. In addition, since short sellers are sophisticated investors with better information (Boehmer, Jones and Zhang, 2008), relaxing short sale constraint enables them to incorporate private information into the market price of IPOs on the offering day. Bad quality firms could not mimic good quality firms as short sellers would detect them and heavily short on their offerings. Issuers therefore have less incentive to underprice IPOs when short sellers could reduce the information asymmetry. We posit that among two-stage IPO firms, those without short sale constraints before the second-stage offering would experience less market overvaluation on the offering day. To summarize, our first hypothesis states:

*H1: The presence of the security lending supply before the second-stage offering would reduce the initial return on the offering day.*

Our second hypothesis examines the effects of short sale constraints on the subsequent long-run performance of IPOs. If the price run-up on the IPO first trading day arises from the market overpricing, the stock price should gradually reverse back to its intrinsic value. Previous studies find that firms with a higher first-day IPO return are likely to be associated with poorer subsequent long-run performance (Stern and Bornstein, 1985; Ritter, 1991; and Loughran and Ritter, 1995). Miller (1977) posits that the gradual relaxation of short sale constraints would allow short

sellers to arbitrage away the initial overpricing in the long-run.<sup>10</sup> Therefore, among two-stage IPO firms, those with a security lending supply before the second-stage offering should have a better long-run performance. To summarize, our second hypothesis posits:

*H2: The presence of the security lending supply before the second-stage offering would improve IPO long-run performance.*

### **3.4. Data and summary statistics**

To test these two hypotheses, we collect data from various sources. In this section, we describe the data sets and present the summary statistics.

#### **3.4.1. Data sources**

We hand collect the introduction information from the LSE new issue data, which are available from 1994. The LSE data provide the following information: date of first-stage introduction, company name, industry classification, and the name of the nominated broker. Since the security lending data are available from January 2002, we consider only introductions that have completed the second-stage offering between January 2002 and December 2013. For each introduction, we hand collect press releases from Factiva. We consider the earliest issuance of primary shares as the second-stage offering, and use the earliest date of news release about this issuance as the second-stage offering announcement day. Importantly, since we examine the role of short sale constraints on the IPO performance using only two-

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<sup>10</sup> There are other explanations for the IPO long-run underperformance, for example, institutional ownership (Brav and Gompers, 1997), underwriter reputation (Carter, Dark and Singh, 1998)), and earnings management (Teoh, Welch, and Wong, 1998). However, our main focus in this paper is to examine the effects of short-sale constraints on IPO long-run performance.

stage IPO firms, our results are not subject to the issue that firms self-select into a two-stage IPO strategy.

We obtain unadjusted closing, bid, and ask prices, trading volume, and shares outstanding from Datastream, net income, operating income and sales data from Datastream and Compustat Global, prospectuses and annual reports from Thomson One Banker and Worldscope. Further, we use Factiva as a supplementary data source if prospectuses and annual reports are missing. Following Derrien and Kecskés (2007), we use the Hoare Govett Smaller Companies (HGSC) index as the market index and obtain the index daily closing price from Datastream.

We use the method in Derrien and Kecskés (2007) to select our sample. First, we match introduction firms with Datastream using company name and listing date. We only keep firms with relevant Datastream information. Next, we eliminate cross-listing stocks, firms that have been traded somewhere else in the world before the introduction, investment trusts and funds, and pure introductions (i.e., firms that were listed at the first-stage introduction but did not complete the second-stage offering within five years after listing). We end up with a sample of 107 introductions.

We obtain security lending data from Markit, a leading provider of security borrowing and lending data. The Markit Securities Finance Data are collected from beneficial owners, lending agents, prime brokers and institutional investors, and are available at daily frequency. Markit covers security lending data for more than 20,000 institutional funds for over ten years of history, which accounts for approximately 85% of the global security lending market.

We use the total lendable shares as our proxy for the security lending supply. Specifically, we define *security lending supply* as the average total shares available

for lending over the previous one week ending the second-stage offering day, divided by total outstanding shares on the second-stage offering day.<sup>11</sup> Among the 107 introductions, 22% have positive security lending supply before the second-stage offering. The average security lending supply before second-stage offering is 12.9% for short-sale unconstrained firms (i.e., firms with positive security lending supply before second-stage offering).

### **3.4.2. Summary statistics**

Table 3.1 presents the year and industry distributions of the 107 introductions. In particular, Panel A shows that short sale unconstrained firms begin their first-stage introduction from 2004. In the empirical analysis, we include year dummy variables in all specifications to account for the potential year differences. Columns (1) and (2) show that first-stage introductions are more prevalent during the 2004 - 2008 period, which is consistent with the increasing number of publicly listing firms before the financial crisis. In particular, the total number of public listing firms in the U.K. has more than doubled from 2003 to 2004 and kept increasing until 2008.

As a result of the increased number of first-stage introductions during the 2004 – 2008 period, a wave of the second-stage offerings could be observed between 2005 and 2009, as reported in Panel B of Table 3.1. Further, Panel C reports the industry distribution of issuers. We define industry groups using the two-digit Standard Industry Classification (SIC) code. We find that the introduction is more popular among mining and service firms, while short sale constrained and unconstrained firms have similar industry distributions.

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<sup>11</sup> Our results remain similar if we define security lending supply as the average total shares available for lending over the previous one month ending the second-stage offering day divided by total outstanding shares on the second-stage offering day.

Table 3.2 presents the main characteristics of the 107 introductions. We winsorize variables at the 99<sup>th</sup> percentiles to mitigate the effects of outliers. We find that the mean *security lending supply* is 12.9% for short sale unconstrained introductions. Further, compared to short sale constrained firms, unconstrained issuers tend to have larger market capitalization, higher proceeds, and higher turnover at the first-stage introduction.

### **3.5. Empirical results**

#### **3.5.1. Univariate analyses**

To assess the relation between short sale constraints and first-day IPO return, we first perform univariate tests. Specifically, we compare the initial return and long-run performance between short sale constrained and unconstrained introductions.

In the first set of tests, we focus on the initial return. We define *initial return* as the market closing price on the second-stage offering day over the offering price, minus one. If short sale constraints before the second-stage offering lead to the market overpricing, we expect short sale unconstrained introductions to have a lower initial return.

Table 3.2 presents the test results for the initial return. Consistent with our expectation, the average initial return of short sale unconstrained introductions (14.7%) is lower than that of constrained introductions (20.3%). This evidence suggests that the relaxation short sale constraints could be associated with smaller initial overpricing. However, the difference is not statistically significant. For comparison, Table 3.2 also reports the average *initial return* for the full sample (i.e., 19.06%), which is higher than the 11.9% reported in Derrien and Kecskés (2007). Since our sample covers the bubble period before the financial crisis, this difference in initial returns could be expected.

One potential explanation for our finding could be that the initial return is positively related to the pricing discount offered by the underwriter. In the second test, we examine this alternative explanation. In particular, we define *pricing discount* as the market price one day before the announcement day of the second-stage offering over the offering price, minus one. In Table 3.2, we show that the average pricing discount is larger for short sale unconstrained introductions. Therefore, pricing discount does not explain the low initial return of short sale unconstrained introductions.

In the second set of tests, we examine the effects of short sale constraints on the long-run performance following the second-stage offering. We measure the long-run performance using annualized market-adjusted three-year buy-and-hold abnormal return (*Market-adjusted-BHAR*), characteristic-adjusted three-year buy-and-hold abnormal return (*Characteristic-adjusted-BHAR*), and four-factor alpha. Specifically, *Market-adjusted- (Characteristic-adjusted-) BHAR* uses the market index (size and book-to-market matched firms) as the benchmark while the four-factor alpha is the intercept of daily regression using the Carhart (1997) four-factor model. If the long-run underperformance is associated with the initial short sale constraints, short sale unconstrained introductions should experience less long-run underperformance.

Consistent with our prediction, we find that short sale unconstrained issuers have better performance in the long-run by using all the three measures. However, these outperformance are not statistically different from zero.

Overall, evidence from univariate tests provides some support for our conjectures. The relaxation of short sale constraints before the second-stage offering

could be associated with lower initial return and better long-run performance for two-stage IPO firms.

### 3.5.2. Initial returns

In this session, we use multivariate analysis to study whether relaxing short sale constraints reduces the initial return of two-stage IPO firms. We start with ordinary least squares (OLS) approach. In particular, we estimate the following reduced-form regression:

$$Initial\ return_i = \alpha_i + \beta_1 Security\ lending\ supply_i + \beta_2 Controls_i + \mu_i. \quad (1)$$

Control variables include several factors that are known to predict IPO initial returns (Derrien and Kecskés, 2007). Among these factors, *Healthy at offering* is a dummy variable that equals to one if a firm has positive sales, operating income, and net income on the second-stage offering day, and zero otherwise. It proxies for the quality of issuers. *Proceeds* is the natural log of proceeds (measured in million pounds) on the second-stage offering day. *Market return at offering* is the market index return over the previous three months ending the day before the second-stage offering day. It proxies for the market condition. Further, to ensure the robustness of our results, we use the *Market-adjusted initial return* as an alternative dependent variable. We define *Market-adjusted initial return* as the difference between the raw initial return and the market return on the second-stage offering day.

Since heterogeneous beliefs could also contribute to the IPO initial price run-up and long-run underperformance (Miller, 1977), we further employ *press coverage* and *relative quoted spread* as additional control variables. We define *press coverage* as the number of press releases in Factiva from the first-stage introduction to the announcement day of the second-stage offering, divided by the number of years in



between. If *press coverage* captures the level of information production (Derrien and Kecskés, 2007), higher press coverage should be associated with smaller opinion dispersion at offering. Further, the previous literature shows that heterogeneous beliefs among investors would create bid-ask spread, which in turn could proxy for opinion dispersion (Houge, Loughran, Suchanek, and Yan, 2001; Handa, Schwartz, and Tiwari, 2003). We define *relative quoted spread* as the difference between the bid and ask prices on the second-stage offering day, divided by the mean of bid and ask prices.

Finally, we control for firm *capitalization at offering* and include year dummy variables to account for the time-variation in initial return. We expect the security lending supply to be negatively correlated with the initial return.

Table 3.3 presents the OLS estimation results of the relation between *security lending supply* and *initial return*. Specifically, Columns (1) and (2) use *initial return* as the dependent variable while Columns (3) and (4) use *market-adjusted initial return* as the dependent variable. We find that, using both dependent variables, security lending supply is negatively associated with the initial return. Further, the coefficients of *press coverage* are significantly negative in all columns, which suggests that greater news coverage could reduce opinion dispersion, and further alleviate the IPO initial price run-up. In economic terms, a one standard deviation increase in *press coverage* is associated with a 3.5% decrease in the initial return in both Columns (2) and (4). Rather, *relative quoted spread* does not have explanatory power for the initial return. Collectively, results in Table 3.3 support our first hypothesis that the existence of the security lending supply before the IPO offering day could reduce the magnitude of the initial return.

The differences in characteristics between short sale constrained and unconstrained two-stage IPO firms raise the concerns about the endogeneity problem. For example, shareholders of a large two-stage IPO firm would be more confident about the second-stage offering, and would in turn be more willing to lend existing shares out. Further, some firm-specific omitted variables could be correlated with the security lending supply while they also affect the IPO initial return or long-run performance.

To account for the potential endogeneity problem, we employ the two-stage ordinary least square (2SLS) estimation using *capitalization at listing* and *turnover at listing* as instrumental variables for the security lending supply. We define *capitalization at listing* as the natural log of firm size (measured in million pounds) at the first-stage introduction, and *turnover at listing* as the mean of daily turnover in the first month following the first-stage introduction. The existing literature suggests that firm size (e.g., D’Avolio, 2002; Geczy, Musto, and Reed, 2002; Kot, 2007; and Kolasinski, Reed, and Ringgenberg, 2013) and stock liquidity (e.g., Duffie, Gârleanu, and Pedersen, 2002; D’Avolio, 2002; and Jones and Lamont, 2002) are positively correlated with the security lending supply, thus satisfying the relevance requirement of instrumental variables. In addition, since the average duration between the first-stage introduction and second-stage offering is 1.3 years, these two instrumental variables are not likely to affect the second-stage initial return and subsequent long-run performance, satisfying the exclusion condition of instrumental variables. For robustness, we also report the results of the limited information maximum likelihood

estimation (i.e., LIML; Anderson and Rubin, 1949; 1950) to examine the finite-sample bias as we have a relative small sample of 107 firms.<sup>12</sup>

To provide additional support for our choice of instrumental variables, for all the 2SLS and LIML regressions, we perform the following two tests: (i) a Kleibergen-Paap (Kleibergen and Paap, 2006) relevance test to ensure high correlations between instrumental variables and security lending supply, and (ii) a Hansen's J over-identification test to examine the exogeneity of the instrumental variables. Test results suggest that both instrumental variables are relevant and exogenous.

Panel A of Table 3.4 reports the instrumental variable estimation results. Columns (1) and (3) use the 2SLS approach, while Columns (2) and (4) implement LIML approach. We find that *turnover at listing* is positively associated with the *security lending supply* in all columns. In contrast, the positive relation between *capitalization at listing* and *security lending supply* only exist by using the 2SLS method. These findings suggest that stocks are likely to have larger *security lending supply* if they are more liquid at the first-stage introduction. Further, firms are likely to be short sale unconstrained if they have a larger size at the first-stage introduction.

Panel B of Table 3.4 presents the second-stage regression estimates. Consistent with our expectation, we find that relaxing short sale constraints could significantly reduce the initial return. In economic terms, a one standard deviation increase of *security lending supply* is associated with a 22.7% decrease of initial return with the 2SLS approach (Column (1) of Table 3.4). Results remain robust if we use the LIML approach or use the *market-adjusted initial return* as the dependent variable.

Further, we find that *press coverage* is negatively correlated with the initial return. Economically, a one standard deviation increase in *press coverage* is

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<sup>12</sup> According to Stock and Yogo (2005), the LIML approach provides the same asymptotic distribution as 2SLS but reduces finite-sample bias. The LIML approach is also claimed to be more resistant to weak instruments problems.

associated with a 5.3% decrease in the IPO initial return (Column (3)). The coefficient of *relative quote*, however, is statistically insignificant in all columns. Consistent with Derrien and Kecskés (2007), we also find that issuers are more likely to have higher initial returns if the market return is high or IPO proceeds are low.

### 3.5.3. Pricing discount

Findings in Section 5.2 indicate that relaxing short sale constraints could be associated with lower initial return. However, we still need to disentangle the market overpricing effect from the pricing discount effect (i.e., underwriters intentionally underprice IPOs during periods of uncertainty and information asymmetry) (Rock, 1986; Benveniste and Spindt, 1989). Specifically, Rock (1986) finds that to ensure uninformed investors would buy the issuance, underwriters would intentionally offer pricing discounts for IPOs.

Therefore, an alternative interpretation of our previous finding could be that the low initial return for short sale unconstrained two-stage IPOs simply reflects less pricing discount from underwriters. Table 3.2 shows that the mean pricing discount is actually larger for short sale unconstrained introductions. In this section we further examine this alternative interpretation by employing multivariate tests. If short sale unconstrained introductions experience less pricing discounts, we would expect the security lending supply or the dummy variable of short sale unconstrained firms to be negatively correlated with the pricing discount.

Table 3.5 reports the effects of the short sale constraints on the pricing discount. In particular, *short sale unconstrained firm* is a dummy variable that equals one if the two-stage IPO firm is short sale unconstrained, and zero otherwise. Control variables include *proceeds*, *market return at announcement*, *healthy at*

*announcement*, *capitalization at announcement*, and *prestigious broker*. *Prestigious broker* is a dummy that equals one if the broker is a global investment bank, and zero otherwise. The announcement day of the second stage offering is defined as the earliest date of news release about the second stage offering we find in Factiva.

Consistent with our prediction, we find no significant relation between pricing discount and short sale constraints. Specifically, *pricing discount* is positively correlated with the market level before the announcement day of the second-stage offering, but negatively correlated with *prestigious broker* dummy variable. This finding is consistent with the existing literature which shows that the prestige of a broker is negatively correlated with the magnitude of IPO underpricing (Chemmanur and Fulghieri, 1994). In Columns (3) and (4) we examine the effect of *security lending supply* on *pricing discount*. Again we do not find any significant relation between *security lending supply* and *pricing discount*. Therefore, pricing discount does not explain our results.<sup>13</sup>

### **3.5.4. Long-run performance**

Our second hypothesis posits that short sale unconstrained introductions would experience better long-run performance. Following Carter, Dark, and Singh (1998), we estimate IPO long-run performance using a three-year horizon. Specifically, the holding period starts from 6 trading days after the second-stage offering day last for 756 days. Since the previous literature shows that IPO long-run performance is sensitive to methodologies (e.g., Barber and Lyon, 1997; Brav and Gompers, 1997), we use different approaches to ensure the robustness of our results.

First, we estimate *market-adjusted-BHAR* using the HGSC Index. Derrien and Kecskés (2007) show that HGSC Index is a standard index for small-cap firms in the

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<sup>13</sup> Our results remain similar if we employ 2SLS and LIML estimation approach.

U.K. As IPOs are normally small-cap at the offering, the index fits characteristics of issuers. Next, motivated by Brav and Gompers (1997) who show that the long-run IPO underperformance could be largely explained by size and book-to-market effects, we estimate *characteristic-adjusted-BHAR* using size and book-to-market matched firms. Matching firms are non-IPO stocks which have at least five years of listing history but do not have follow-on equity issuance five years before the matching date.

If the best-matching firm is delisted during our three-year estimation window, we use the second-best matching firm instead. Specifically, the three-year long-run performance is calculated as follows:

$$BHAR_i = \left[ \left( \prod_{t=offering\ day+6}^{\min[T, end\ of\ sample\ period]} (1 + r_{i,t}) \right) - \left( \prod_{t=offering\ day+6}^{\min[T, end\ of\ sample\ period]} (1 + r_{m,t}) \right) \right] \times 100, \quad (2)$$

where  $r_{i,t}$  is the return of stock  $i$  on day  $t$ ;  $T$  equals to offering date + 762 trading days;  $r_{m,t}$  is the corresponding benchmark return (i.e., market index or matching firm return) on day  $t$ . Both *market-adjusted-BHAR* and *characteristic-adjusted-BHAR* are annualized after estimation.<sup>14</sup> To further ensure the robustness of our results, we use a third method to measure the long-run performance, i.e., the Carhart (1997) four-factor model:

$$r_{i,t} - R_{f,t} = \alpha_i + \beta_1(R_{m,t} - R_{f,t}) + \beta_2SMB_t + \beta_3HML_t + \beta_4UMD_t + \varepsilon_{i,t}, \quad (3)$$

where  $r_{f,t}$  is the risk free rate on day  $t$ ;  $R_{m,t} - R_{f,t}$  is the excess market portfolio return on day  $t$ ;  $SMB_t$ ,  $HML_t$ , and  $UMD_t$  stand for the size, value and momentum factors on

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<sup>14</sup> Among the 107 introductions, no firm is delisted within three years after the second-stage offering. Therefore, our results do not have survival bias. However, three firms completed the second-stage offering later than October 2011 and therefore have a trading history of less than three years. To avoid selection bias, we keep these stocks and use the last day of our sample, 31st October 2014, as the ending day of their holding period. Our results remain similar if we exclude these three stocks.

day  $t$ .<sup>15</sup> The daily excess return  $\alpha_i$  is annualized to simplify the interpretation of following regression coefficients.

Table 3.6 presents the simple OLS regression results. We find that the security lending supply has significantly positive influences using all the measurements of IPO long-run performance. In economic terms, a one standard deviation increase in *security lending supply* is associated with a 10.1% (19.5%) increase in *market-adjusted-BHAR* (*characteristic-adjusted-BHAR*). Further, for the Carhart (1997) four-factor alpha, a one standard deviation increase in *security lending supply* is associated with an abnormal return of 11.3%. These results remain robust after the inclusion of additional control variables. In terms of opinion dispersion, we find that the coefficient estimates of press coverage and relative quoted spread are insignificant in all columns.

Table 3.7 presents the estimation results by using the 2SLS and LIML approaches. In Panel A, we find that the first-stage regression results are similar to the results in the initial return analysis. Stocks with larger capitalization and higher turnover at the first-stage introduction are more likely to have security lending supply. The  $f$ -statistic is 20.5 for all the models. Further, the Hansen-J statistics suggest that none of our models rejects the null hypothesis of exogeneity of the instruments. Therefore, our instrumental variables are valid in all long-run performance models.

Panel B of Table 3.7 presents the second-stage regression results. Consistent with our expectation, we find that *security lending supply* is positively correlated with IPO long-run performance by using all the three long-run performance measures. Specifically, Columns (1) and (2) reports effects of *security lending supply* on *market-adjusted-BHAR*. In economic terms, with the 2SLS approach, a one standard

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<sup>15</sup> We use the size, value and momentum factors constructed for the U.K. market by Gregory, Tharyan, and Christidis (2013).

deviation increase in *security lending supply* is associated with a 29.6% increase in *market-adjusted-BHAR*. Results are similar if we use *characteristic-adjusted-BHAR* or the Carhart (1997) four-factor alpha as long-run performance measure. Further, our findings remain robust with the LIML approach, which suggests that our estimations do not suffer small-sample bias. In terms of opinion dispersion, the coefficient of *relative quoted spread* and *press coverage* are insignificant in all the eight columns.

Overall, these findings indicate that relaxing short sale constraints improves IPO long-run performance.

### **3.5.5. Robustness tests and alternative explanations**

In this section, we check the robustness of our results. First, we employ a full maximum likelihood estimation (MLE) treatment effect model, which simultaneously estimates a binary choice model and the main model. The binary choice model is a probit model which regresses *short sale unconstrained firm* (i.e., a dummy variable indicating whether the two-stage IPO firm is short sale unconstrained) on factors that are likely to influence decisions of security lenders (i.e., *turnover at listing* and *capitalization at listing*). The main model provides unbiased estimates of effects of relaxing short sale constraints on the IPO initial return and long-run performance.

Panel A of Table 3.8 reports the probit model estimation results. We find that two-stage IPO firms with larger size and higher turnover at the first-stage listing are more likely to be short sale unconstrained. We also report the chi-square tests of  $\rho = 0$  in Panel A, since a violation of the assumption that the correlation between the error terms of the selection and main models does not equal to zero could lead to



biased results. In our test, the null hypothesis that the two equations are independent is rejected for all the MLE models. Therefore, our MLE estimations are appropriate.

Panel B of Table 3.8 presents the results for the jointly estimated treatment effects models. Columns (1) and (2) report estimation results for the initial return. The coefficient of *short sale unconstrained firm* ranges from -29% to -29.1%, indicating that relaxing short sale constraints alleviates the market overpricing on the IPO offering day. Columns (3) to (5) report estimation results for the long-term performance. The coefficients on the *short sale unconstrained firm* dummy are all significantly positive, which is consistent with our main results in Table 3.7. Overall, our test results of *H1* and *H2* remain robust with the MLE estimation.

One alternative explanation of our main results could be that the security lending supply provides liquidity to the market on the second-stage offering day and therefore reduces the illiquidity premium of the new issuance. Amihud (2002) shows that market illiquidity is positively associated with the stock excess return, and this effect is stronger in smaller stocks. If this is the case, then we should observe that the security lending supply promotes the liquidity of introductions on the second-stage offering day.

Table 3.9 reports our OLS estimation results for this alternative explanation. We use the bid-ask spread and turnover on the second-stage issuance day as two measurements of the IPO liquidity. In Columns (1) and (3), we find that there is no significant difference between the liquidity for short sale constrained and unconstrained introductions on the second-stage offering day. In Columns (2) and (4), the coefficients of *security lending supply* are statistically insignificant, indicating that short sale constraints do not have significant influence on IPO

liquidity on the second-stage offering day. Therefore, liquidity premium does not explain our results.

### **3.6. Conclusion**

This study investigates the effects of relaxing short sale constraints on the first-day IPO return and subsequent long-run performance by using a set of two-stage IPOs, named as introductions. In an introduction, public listing and initial share offering are separated into two stages. This feature enables the security lending supply to exist before the second-stage offering, leaving us a natural design to directly examine the effects of relaxing short sale constraints on IPO-related puzzles. We find that short sale unconstrained IPOs experience less initial price run-up and better long-run performance.

Our findings provide new evidence in the debate on the theoretical model developed in Miller (1977) which posits that short sale constraints could lead to the IPO initial price run-up. In our sample, the short sale unconstrained IPOs have 12.9% of outstanding shares available for borrowing before the second-stage offering day. We find that short sale unconstrained two-stage IPOs experience less initial price run-up and better long-run performance than their counterparts. Our findings support the assumption that short sale constraints could be associated with the IPO initial price run-up and subsequent long-run underperformance (Miller 1977; Derrien 2005; Ljungqvist, Nanda, and Singh, 2006).

Our findings also demonstrate that short selling could improve pricing efficiency (Boehmer, Jones, and Zhang, 2008; Saffi and Sigurdsson, 2010; and Boehmer and Wu, 2013). We find that relaxing short sale constraints improves the IPO pricing efficiency on the offering day. This evidence contributes to the short selling

literature, and further supports the positive role of short selling in the financial market.

Our findings have important implications for market designers and practitioners. By extending the findings in Derrien and Kecskés (2007), we further show that the two-stage IPO strategy could be an effective way for firms to go public. Investors may consider going public with this strategy to enjoy possible benefits from relaxed short sale constraints.

**Table 3.1 : Firm and industry distributions**

This table presents the firm year and industry distributions. Our sample includes 107 U.K. introductions that completed their second-stage offering between January 2002 and December 2013. Panel A reports the year distribution for introductions at the first-stage introduction; Panel B reports the year distribution for introductions at the second-stage offering; and Panel C reports the industry distribution. Specifically, Columns (1) and (2) pertain to the full sample, 107 introductions, Columns (3) and (4) to the 83 short sale constrained introductions, and Columns (5) and (6) to the 24 short sale unconstrained introductions. We define short sale unconstrained introductions as those with a positive security lending supply over the previous one week ending the second-stage offering day.

Panel A: Number and percentage by first-stage listing year

Year	Full sample		Short sale constrained		Short sale unconstrained	
	(1) Number	(2) %	(3) Number	(4) %	(5) Number	(6) %
1999	2	1.9%	2	2.4%	0	0.0%
2000	3	2.8%	3	3.6%	0	0.0%
2001	4	3.7%	4	4.8%	0	0.0%
2002	3	2.8%	3	3.6%	0	0.0%
2003	3	2.8%	3	3.6%	0	0.0%
2004	19	17.8%	15	18.1%	4	16.7%
2005	20	18.7%	18	21.7%	2	8.3%
2006	24	22.4%	20	24.1%	4	16.7%
2007	13	12.2%	9	10.8%	4	16.7%
2008	8	7.5%	3	3.6%	5	20.8%
2009	0	0.0%	0	0.0%	0	0.0%
2010	4	3.5%	2	2.4%	2	8.3%
2011	3	2.8%	1	1.2%	2	8.3%
2012	1	0.9%	0	0.0%	1	4.2%
Total	107		83		24	

**Table 3.1 (Cont'd)**

Panel B: Number and percentage by second-stage offering year

Year	Full sample		Short sale constrained		Short sale unconstrained	
	(1) Number	(2) %	(3) Number	(4) %	(5) Number	(6) %
2002	7	6.5%	7	8.4%	0	0.0%
2003	3	2.8%	3	3.6%	0	0.0%
2004	6	5.6%	6	7.2%	0	0.0%
2005	19	17.8%	16	19.3%	3	12.5%
2006	19	17.8%	19	22.9%	0	0.0%
2007	21	19.6%	16	19.3%	5	20.8%
2008	6	5.6%	3	3.6%	3	12.5%
2009	10	9.4%	6	7.2%	4	16.7%
2010	5	4.7%	3	3.6%	2	8.3%
2011	7	6.5%	2	2.4%	5	20.8%
2012	2	1.9%	1	1.2%	1	4.2%
2013	2	1.9%	1	1.2%	1	4.2%
Total	107		83		24	

Panel C: Number and percentage by industry

Industry	Full sample		Short sale constrained		Short sale unconstrained	
	(1) Number	(2) %	(3) Number	(4) %	(5) Number	(6) %
<i>Mining</i>	30	28.0%	25	30.1%	5	20.8%
<i>Construction</i>	1	0.9%	1	1.2%	0	0.0%
<i>Manufacturing</i>	18	16.8%	15	18.1%	3	12.5%
<i>Transportation</i>	8	7.5%	3	3.6%	5	20.8%
<i>Wholesale</i>	1	0.9%	1	1.2%	0	0.0%
<i>Retail</i>	5	4.7%	4	4.8%	1	4.2%
<i>Finance insurance</i>	18	16.8%	13	15.7%	5	20.8%
<i>real estate</i>						
<i>Services</i>	26	24.3%	21	25.3%	5	20.8%
Total	107		83		24	

**Table 3.2 : Summary statistics**

This table presents summary statistics. Our sample includes 107 U.K. introductions that completed their second-stage offering between January 2002 and December 2013. Column (1) pertains to our full sample, Column (2) to the 83 short sale constrained introductions, and Column (3) to the 24 short sale unconstrained introductions. We define short sale unconstrained introductions as those with a positive security lending supply over the previous one week ending the second-stage offering day. Columns (4) and (5) report the t-statistics for tests of the mean difference and the z-statistics of the Wilcoxon two-sample test. *Security lending supply* is the total shares available for lending over total outstanding shares. We define *capitalization at listing* as the natural log of firm size (measured in million pounds) at the first-stage introduction, *turnover at listing* as the mean of daily turnover in the first month following the first-stage introduction, *proceeds* as the natural log of the proceeds (measured in million pounds) at the second-stage offering, and *capitalization at offering* as the natural log of firm size (measured in million pounds) at the second-stage offering. Further, we define *press coverage* as the number of press releases in Factiva from the first-stage introduction to the announcement day of the second-stage offering, divided by the number of years in between, *relative quoted spread* as the difference between the bid and ask prices on the second-stage offering day, divided by the mean of bid and ask prices, *pricing discount* as the market price one day before the announcement day of the second-stage offering over the offering price, minus one, *initial return* as the market closing price on the second-stage offering day over the offering price, minus one, and *market-adjusted initial return* as the difference between the raw initial return and the market return on the second-stage offering day. *Market-adjusted-BHAR* is the annualized three year buy-and-hold abnormal return using the market index as the benchmark. *Characteristic-adjusted-BHAR* is the annualized three year buy-and-hold abnormal return using size and book-to-market ratio matched firms as the benchmark. *Four-factor-alpha* is the annualized excess return measured as the intercept of daily return regressions by using the Carhart (1997) four-factor model as the benchmark. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Variables	(1) Full sample	(2) Short sale constrained introductions	(3) Short sale unconstrained introductions	(4) t-statistics for tests of mean difference	(5) z-statistics of the Wilcoxon two- sample test
<i>Security lending supply (%)</i>					
Mean			12.86		
Median			7.26		
Std. Dev.			16.80		
<i>Capitalization at listing (£ millions)</i>					
Mean	145.19	65.27	418.26	<b>-2.950***</b>	
Median	17.45	12.37	117.49		<b>-5.235***</b>
Std. Dev.	387.45	273.29	567.19		
<i>Turnover at listing</i>					
Mean	0.47	0.31	0.99	<b>-2.496***</b>	
Median	0.18	0.13	0.52		<b>-2.668***</b>
Std. Dev.	0.79	0.46	1.29		
<i>Proceeds (£ millions)</i>					
Mean	16.99	5.49	56.78	<b>-3.096***</b>	
Median	1.81	0.78	25.42		<b>-5.489***</b>
Std. Dev.	46.18	18.42	80.56		

**Table 3.2(Cont'd)**

Variables	(1) Full sample	(2) Short sale constrained introductions	(3) Short sale unconstrained introductions	(4) t-statistics for tests of mean difference	(5) z-statistics of the Wilcoxon two- sample test
<i>Capitalization at offering (£ millions)</i>					
Mean	210.24	87.17	635.85	<b>-2.786***</b>	
Median	16.06	10.13	140.11		<b>-5.463***</b>
Std. Dev.	607.52	400.73	940.63		
<i>Press coverage</i>					
Mean	82.43	72.40	117.10	<b>-1.102</b>	
Median	30.42	23.89	63.48		<b>-2.601***</b>
Std. Dev.	175.22	184.55	135.83		
<i>Relative quoted spread (%)</i>					
Mean	13.71	16.71	3.35	<b>5.469***</b>	
Median	7.79	9.53	1.33		<b>5.344***</b>
Std. Dev.	19.22	20.78	4.29		
<i>Pricing discount (%)</i>					
Mean	15.69	15.34	17.07	<b>0.851</b>	
Median	10.52	12.50	8.75		<b>0.316</b>
Std. Dev.	37.38	41.23	23.64		
<i>Initial return (%)</i>					
Mean	19.06	20.31	14.73	<b>0.933</b>	
Median	14.17	15.00	5.48		<b>0.945</b>
Std. Dev.	37.71	41.60	18.97		
<i>Market-adjusted initial return (%)</i>					
Mean	18.99	20.27	14.56	<b>0.955</b>	
Median	13.77	14.97	4.74		<b>1.031</b>
Std. Dev.	37.61	41.47	18.99		
<i>Market-adjusted-BHAR (%)</i>					
Mean	-10.18	-11.14	-6.84	<b>-0.732</b>	
Median	-12.88	-12.88	-7.17		<b>-0.545</b>
Std. Dev.	25.28	24.96	26.60		
<i>Characteristic-adjusted- BHAR (%)</i>					
Mean	-11.94	-15.46	0.22		
Median	-11.91	-11.39	-12.52	<b>-1.341</b>	<b>-0.904</b>
Std. Dev.	50.66	54.37	33.05		
<i>Four-factor-alpha (%)</i>					
Mean	-8.74	-9.04	-7.72	<b>-0.151</b>	
Median	-4.77	-6.97	6.85		<b>-0.657</b>
Std. Dev.	37.42	38.25	35.13		

**Table 3.3 : Initial return for short sale constrained and unconstrained introductions - OLS estimations**

This table presents the difference in initial returns between short sale constrained and unconstrained introductions. Our sample includes 107 U.K. introductions that completed their second-stage offering between January 2002 and December 2013. We use the OLS regression as our estimation method:

$$\text{Initial return}_i = \alpha_i + \beta_1 \text{Security lending supply}_i + \beta_2 \text{Controls}_i + \mu_i.$$

*Security lending supply* is the total shares available for lending over total outstanding shares. *Proceeds* is the natural log of the proceeds (measured in million pounds) at the second-stage offering. *Healthy at offering* is a dummy variable that equals to one if a firm has positive sales, operating income, and net income on the second-stage offering day, and zero otherwise. *Market return at offering* is the market index return from previous three months until the day before the second-stage offering day. *Press coverage* is the number of press releases in Factiva from the first-stage introduction to the announcement day of the second-stage offering, divided by the number of years in between. *Relative quoted spread* is the difference between the bid and ask prices on the second-stage offering day, divided by the mean of bid and ask prices. *Capitalization at offering* is the natural log of firm size (measured in million pounds) at the second-stage offering. Columns (1) and (2) use *initial return* as the dependent variable, which is defined as the market closing price on the second-stage offering day over the offering price, minus one. Columns (3) and (4) use *market-adjusted initial return* as dependent variable, which is defined as the difference between the raw initial return and the market return on the second-stage offering day. All columns include offering year dummy variables. Standard errors (reported in parentheses) are clustered by industry. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Variable	(1) Initial return	(2) Initial return	(3) Market-adjusted initial return	(4) Market-adjusted initial return
<i>Security lending supply</i>	<b>-0.52***</b> (0.11)	<b>-0.20**</b> (0.07)	<b>-0.52***</b> (0.11)	<b>-0.20**</b> (0.08)
<i>Proceeds</i>		<b>-5.78***</b> (1.05)		<b>-5.74***</b> (1.08)
<i>Healthy at offering</i>		<b>-6.06</b> (6.03)		<b>-6.41</b> (6.10)
<i>Market return at offering</i>		<b>1.49***</b> (0.18)		<b>1.49***</b> (0.18)
<i>Press coverage</i>		<b>-0.02**</b> (0.01)		<b>-0.02**</b> (0.01)
<i>Relative quoted spread</i>		<b>-0.20</b> (0.13)		<b>-0.21</b> (0.14)
<i>Capitalization at offering</i>		<b>1.30</b> (2.18)		<b>1.24</b> (2.25)
<i>Constant</i>	<b>20.02**</b> (7.17)	<b>40.63***</b> (6.69)	<b>20.12**</b> (7.04)	<b>41.16***</b> (6.81)
<i>Number of observations</i>	107	107	107	107
<i>R<sup>2</sup></i>	0.09	0.23	0.09	0.23



**Table 3.4 : Initial return for short sale constrained and unconstrained introductions – IV estimations**

This table presents the difference in initial returns between short sale constrained and unconstrained introductions. Our sample includes 107 U.K. introductions that completed their second-stage offering between January 2002 and December 2013. We use the 2SLS model to control for endogeneity problem while also report the LIML estimation results for robustness. Panel A reports the first-stage regression results from the 2SLS approach and the reduced form estimation results from the LIML approach. Exogenous instrumental variables are discussed in Section 5. *Capitalization at listing* is the natural log of firm size (measured in million pounds) at the first-stage introduction. *Turnover at listing* is the mean of daily turnover in the first month following the first-stage introduction. Panel B reports the second-stage regression results. Specifically, the 2SLS model is as follows:

$$\text{Security lending supply}_i = \delta_i + \pi_1 \text{Capitalization at listing}_i + \pi_2 \text{Turnover at listing}_i + \pi_3 \text{Controls}_i + \varepsilon_i,$$

$$\text{Initial return}_i = \alpha_i + \beta_1 \widehat{\text{Security lending supply}}_i + \beta_2 \text{Controls}_i + \mu_i.$$

Variables are as defined in Table 3. All columns include offering year dummy variables. Standard errors (reported in parentheses) are clustered by industry. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Dependent variable is security lending supply

	(1)	(2)	(3)	(4)
	Initial return	Initial return	Market-adjusted initial return	Market-adjusted initial return
Variable	2SLS	LIML	2SLS	LIML
<i>Capitalization at listing</i>	<b>1.96*</b> (1.01)	<b>1.96</b> (1.18)	<b>1.96*</b> (1.01)	<b>1.96</b> (1.18)
<i>Turnover at listing</i>	<b>2.77***</b> (0.73)	<b>2.77***</b> (0.58)	<b>2.77***</b> (0.73)	<b>2.77***</b> (0.58)
<i>Number of observations</i>	103	103	103	103
<i>Kleibergen-Paap Wald F statistic</i>	<b>38.23***</b>	<b>38.23***</b>	<b>38.23***</b>	<b>38.23***</b>
<i>R<sup>2</sup></i>	0.33	0.33	0.33	0.33

**Table 3.4 (Cont'd)**

Panel B: Dependent variable is initial return

	(1)	(2)	(3)	(4)
	Initial return	Initial return	Market-adjusted initial return	Market-adjusted initial return
Variable	2SLS	LIML	2SLS	LIML
<i>Security lending supply</i>	<b>-1.35**</b> (0.55)	<b>-1.54***</b> (0.64)	<b>-1.41***</b> (0.54)	<b>-1.60***</b> (0.63)
<i>Proceeds</i>	<b>-4.96***</b> (0.70)	<b>-4.78***</b> (0.74)	<b>-4.90***</b> (0.71)	<b>-4.73***</b> (0.74)
<i>Healthy at offering</i>	<b>-4.39**</b> (1.90)	<b>-3.88**</b> (1.80)	<b>-4.62**</b> (1.88)	<b>-4.10**</b> (1.80)
<i>Market return at offering</i>	<b>1.42***</b> (0.17)	<b>1.41***</b> (0.17)	<b>1.41***</b> (0.17)	<b>1.40***</b> (0.17)
<i>Capitalization at offering</i>	<b>3.79</b> (2.38)	<b>4.08*</b> (2.46)	<b>3.88</b> (2.39)	<b>4.19*</b> (2.46)
<i>Press coverage</i>	<b>-0.03***</b> (0.01)	<b>-0.03***</b> (0.01)	<b>-0.03***</b> (0.01)	<b>-0.03***</b> (0.01)
<i>Relative quoted spread</i>	<b>-0.10</b> (0.06)	<b>-0.09</b> (0.06)	<b>-0.10</b> (0.06)	<b>-0.09</b> (0.06)
<i>Constant</i>	<b>27.85**</b> (12.16)	<b>26.14**</b> (13.17)	<b>27.55**</b> (12.10)	<b>25.80**</b> (13.08)
<i>Number of observations</i>	103	103	103	103
<i>Hansen's J over- identification test (p-value)</i>	0.12	0.13	0.12	0.13

**Table 3.5 : Pricing discount for short sale constrained and unconstrained introductions - OLS estimations**

This table presents the difference in pricing discounts between short sale constrained and unconstrained introductions. Our sample includes 107 U.K. introductions that completed their second-stage offering between January 2002 and December 2013. We use the OLS regression as our estimation method:

$$\text{Pricing discount}_i = \alpha_i + \beta_1 \text{Security lending supply}_i + \beta_2 \text{Controls}_i + \mu_i.$$

*Pricing discount* is the market price one day before the announcement day of the second-stage offering over the offering price, minus one. *Short sale unconstrained firm* is a dummy variable that equals one if the two-stage IPO firm is short sale unconstrained, and zero otherwise. Other variables are as defined in Table 3. All columns include offering year dummy variables. Standard errors (reported in parentheses) are clustered by industry. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Variable	(1) Pricing discount	(2) Pricing discount	(3) Pricing discount	(4) Pricing discount
<i>Short sale unconstrained firm</i>	<b>3.99</b> (10.84)	<b>18.55</b> (10.69)		
<i>Security lending supply</i>			<b>-0.24</b> (0.20)	<b>0.28</b> (0.15)
<i>Prestigious broker</i>		<b>-22.48***</b> (2.49)		<b>-20.06***</b> (1.75)
<i>Proceeds</i>		<b>-3.44*</b> (1.75)		<b>-3.29**</b> (1.34)
<i>Healthy at announcement</i>		<b>-5.52</b> (9.21)		<b>-5.62</b> (8.39)
<i>Market return at announcement</i>		<b>1.17**</b> (0.51)		<b>1.20**</b> (0.49)
<i>Capitalization at announcement</i>		<b>0.83</b> (2.68)		<b>1.69</b> (2.47)
Constant	<b>20.60**</b> (5.84)	<b>39.44**</b> (11.67)	<b>20.60**</b> (5.84)	<b>30.57**</b> (10.89)
<i>Number of observations</i>	104	104	104	104
<i>R<sup>2</sup></i>	0.07	0.15	0.07	0.14

**Table 3.6 : Long-run performance of short sale constrained and unconstrained introductions - OLS estimations**

This table presents the difference in the long-run performance between short sale constrained and unconstrained introductions. Our sample includes 107 U.K. introductions that completed their second-stage offering between January 2002 and December 2013. We use the OLS regression as our estimation method:

$$\text{Long run abnormal return}_i = \alpha_i + \beta_1 \text{Security lending supply}_i + \beta_2 \text{Controls}_i + \mu_i.$$

Long-run abnormal return is measured as *Market-adjusted-BHAR*, *Characteristic-adjusted-BHAR* or *Four-factor-alpha*. Specifically, *market-adjusted-BHAR* is the annualized three year buy-and-hold abnormal return using the market index as the benchmark. *Characteristic-adjusted-BHAR* is the annualized three year buy-and-hold abnormal return using size and book-to-market ratio matched firms as the benchmark. *Four-factor-alpha* is the annualized excess return measured as the intercept of daily return regressions by using the Carhart (1997) four-factor model as the benchmark. *B/M* is the book-to-market ratio at the second-stage offering. *Volatility* is the standard deviation of daily stock returns during the year following the second-stage offering, excluding the first trading week. Other variables are as defined in Table 3. All columns include offering year dummy variables. Standard errors (reported in parentheses) are clustered by industry. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Variable	(1) Market-adjusted- BHAR	(2) Market-adjusted- BHAR	(3) Characteristic- adjusted-BHAR	(4) Characteristic- adjusted-BHAR	(5) Four-factor-alpha	(6) Four-factor- alpha
<i>Security lending supply</i>	<b>0.60***</b> (0.17)	<b>0.48**</b> (0.18)	<b>1.16**</b> (0.43)	<b>1.38***</b> (0.38)	<b>0.67***</b> (0.18)	<b>0.79**</b> (0.26)
<i>Proceeds</i>		<b>-0.09</b> (2.56)		<b>-2.14</b> (2.94)		<b>-0.19</b> (3.83)
<i>Healthy at offering</i>		<b>14.30</b> (7.99)		<b>21.75</b> (15.48)		<b>18.41</b> (12.62)
<i>B/M</i>		<b>7.60</b> (7.64)		<b>4.40</b> (8.74)		<b>9.31</b> (7.06)
<i>Capitalization at offering</i>		<b>-2.04</b> (3.30)		<b>-3.96</b> (5.26)		<b>-1.79</b> (5.35)
<i>Volatility</i>		<b>-1.96</b> (1.15)		<b>-6.22***</b> (1.69)		<b>1.31</b> (3.04)

**Table 3.6 (Cont'd)**

<i>Press coverage</i>		<b>0.00</b> (0.01)		<b>-0.04</b> (0.05)		<b>-0.01</b> (0.01)
<i>Relative quoted spread</i>		<b>-0.14</b> (0.20)		<b>0.05</b> (0.20)		<b>0.34</b> (0.38)
Constant	<b>-13.79</b> (13.87)	<b>-10.44</b> (12.86)	<b>-6.69</b> (6.79)	<b>26.76</b> (18.60)	<b>-6.35</b> (14.41)	<b>-18.64</b> (18.64)
<i>Number of observations</i>	107	99	107	99	107	99
<i>R</i> <sup>2</sup>	0.17	0.33	0.11	0.26	0.08	0.19

**Table 3.7 : Long-run performance of short sale constrained and unconstrained introductions - IV estimations**

This table presents the difference in the long-run performance between short sale constrained and unconstrained introductions. Our sample includes 107 U.K. introductions that completed their second-stage offering between January 2002 and December 2013. We use the 2SLS model to control for endogeneity problem while also report the LIML estimation results for robustness. Panel A reports the first-stage regression results from the 2SLS approach and the reduced form estimation results from the LIML approach. Exogenous instrumental variables are discussed in Section 5. *Capitalization at listing* is the natural log of firm size (measured in million pounds) at the first-stage introduction. *Turnover at listing* is the mean of daily turnover in the first month following the first-stage introduction. Panel B reports the second-stage regression results. Specifically, the 2SLS model is as follows:

$$\text{Security lending supply}_i = \delta_i + \pi_1 \text{Capitalization at listing}_i + \pi_2 \text{Turnover at listing}_i + \pi_3 \text{Controls}_i + \varepsilon_i$$

$$\text{Long run abnormal return}_i = \alpha_i + \beta_1 \text{Security lending supply}_i + \beta_2 \text{Controls}_i + \mu_i.$$

Variables are as defined in Tables 3 and 6. All columns include offering year dummy variables. Standard errors (reported in parentheses) are clustered by industry. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Dependent variable is security lending supply

Variable	(1) Market-adjusted- BHAR 2SLS	(2) Market-adjusted- BHAR LIML	(3) Characteristic- adjusted-BHAR 2SLS	(4) Characteristic- adjusted-BHAR LIML	(5) Four-factor-alpha 2SLS	(6) Four-factor-alpha LIML
<i>Capitalization at listing</i>	<b>2.01*</b> (1.12)	<b>2.01*</b> (1.12)	<b>2.01*</b> (1.12)	<b>2.01*</b> (1.12)	<b>2.01*</b> (1.12)	<b>2.01*</b> (1.12)
<i>Turnover at listing</i>	<b>2.85***</b> (0.81)	<b>2.85***</b> (0.81)	<b>2.85***</b> (0.81)	<b>2.85***</b> (0.81)	<b>2.85***</b> (0.81)	<b>2.85***</b> (0.81)
<i>Number of observations</i>	95	95	95	95	95	95
<i>Kleibergen-Paap Wald F statistic</i>	<b>20.50***</b>	<b>20.50***</b>	<b>20.50***</b>	<b>20.50***</b>	<b>20.50***</b>	<b>20.50***</b>
<i>R<sup>2</sup></i>	0.34	0.34	0.34	0.34	0.34	0.34

**Table 3.7 (Cont'd)**

Panel B: Dependent variable is long-run returns

Variable	(1) Market-adjusted- BHAR 2SLS	(2) Market-adjusted- BHAR LIML	(3) Characteristic-adjusted- BHAR 2SLS	(4) Characteristic-adjusted- BHAR LIML	(5) Four-factor- alpha 2SLS	(6) Four-factor- alpha LIML
<i>Security lending supply</i>	<b>1.76***</b> (0.63)	<b>1.83***</b> (0.67)	<b>5.65***</b> (1.22)	<b>5.93***</b> (1.31)	<b>2.86**</b> (1.18)	<b>2.91**</b> (1.22)
<i>Proceeds</i>	<b>-1.79</b> (2.57)	<b>-1.87</b> (2.58)	<b>-7.24*</b> (3.71)	<b>-7.55**</b> (3.79)	<b>-2.70</b> (4.25)	<b>-2.76</b> (4.28)
<i>Healthy at offering</i>	<b>13.19**</b> (6.15)	<b>12.98**</b> (6.20)	<b>12.34</b> (16.04)	<b>11.52</b> (16.36)	<b>16.72*</b> (10.07)	<b>16.54</b> (10.12)
<i>B/M</i>	<b>8.18</b> (7.30)	<b>8.23</b> (7.34)	<b>6.40</b> (10.51)	<b>6.56</b> (10.68)	<b>9.72</b> (7.25)	<b>9.76</b> (7.28)
<i>Capitalization at offering</i>	<b>-3.36</b> (3.24)	<b>-3.45</b> (3.26)	<b>-9.78*</b> (5.20)	<b>-10.13*</b> (5.30)	<b>-4.12</b> (4.56)	<b>-4.20</b> (4.56)
<i>Volatility</i>	<b>-1.42</b> (1.08)	<b>-1.42</b> (1.09)	<b>-6.11***</b> (1.33)	<b>-6.12***</b> (1.33)	<b>1.98</b> (2.85)	<b>1.97</b> (2.85)
<i>Press coverage</i>	<b>0.00</b> (0.01)	<b>0.00</b> (0.01)	<b>-0.03</b> (0.04)	<b>-0.03</b> (0.04)	<b>-0.01</b> (0.01)	<b>-0.01</b> (0.01)
<i>Relative quoted spread</i>	<b>-0.12</b> (0.18)	<b>-0.12</b> (0.19)	<b>-0.07</b> (0.21)	<b>-0.08</b> (0.21)	<b>0.42</b> (0.35)	<b>0.42</b> (0.35)
Constant	<b>-4.10</b> (19.10)	<b>-3.54</b> (19.44)	<b>60.91**</b> (28.47)	<b>63.12**</b> (29.62)	<b>-7.78</b> (28.36)	<b>-7.30</b> (28.60)
<i>Number of observations</i>	95	95	95	95	95	95
<i>Hansen's J over-identification test (p-value)</i>	0.61	0.61	0.56	0.56	0.63	0.63

**Table 3.8 : Robustness tests – MLE estimations**

This table presents the difference in the long-run performance between short sale constrained and unconstrained introductions. Our sample includes 107 U.K. introductions that completed their second-stage offering between January 2002 and December 2013. We use full maximum likelihood estimation (MLE) to control for self-selection problem:

$$\text{Short sale unconstrained firm}_i = \delta_i + \pi_1 \text{Capitalization at listing}_i + \pi_2 \text{Turnover at listing}_i \\ + \pi_3 \text{Controls}_i + \varepsilon_i,$$

$$\text{Initial return}_i = \alpha_i + \beta_1 \text{Short sale unconstrained firm}_i + \beta_2 \text{Controls}_i + \mu_i,$$

$$\text{Long run abnormal return}_i = \alpha_i + \beta_1 \text{Short sale unconstrained firm}_i + \beta_2 \text{Controls}_i + \mu_i.$$

Variables are as defined in Tables 3 and 6. Panel A reports probit regression results from the selection model. *Short sale unconstrained firm* is a dummy variable that equals one if the two-stage IPO firm is short sale unconstrained, and zero otherwise. Panel B reports the jointly estimated main model results. All columns include offering year dummy variables. Standard errors (reported in parentheses) are clustered by industry. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Dependent variable is short sale unconstrained firm dummy

Variable	(1) Initial return	(2) Market-adjusted-initial return	(3) Market-adjusted- BHAR	(4) Characteristic-adjusted- BHAR	(5) Four-factor-alpha
<i>Capitalization at listing</i>	<b>0.44***</b> (0.08)	<b>0.44***</b> (0.08)	<b>0.37***</b> (0.05)	<b>0.43***</b> (0.06)	<b>0.41***</b> (0.07)
<i>Turnover at listing</i>	<b>0.45***</b> (0.17)	<b>0.45***</b> (0.17)	<b>0.53***</b> (0.08)	<b>0.57***</b> (0.08)	<b>0.65***</b> (0.06)
<i>Number of observations</i>	103	103	95	95	95
$\rho$	0.48	0.48	-0.85	-0.37	-0.68
<i>chi-square test of <math>\rho = 0</math> (p-value)</i>	<b>0.03**</b>	<b>0.02**</b>	<b>0.08*</b>	<b>0.00***</b>	<b>0.00***</b>



**Table 3.8 (Cont'd)**

Panel B: Dependent variable is initial return/long-run returns

Variable	(1) Initial return	(2) Market-adjusted-initial return	(3) Market-adjusted- BHAR	(4) Characteristic-adjusted- BHAR	(5) Four-factor-alpha
<i>Short sale unconstrained firm</i>	<b>-28.92**</b> (13.48)	<b>-29.14**</b> (13.14)	<b>33.60***</b> (13.01)	<b>48.73***</b> (13.51)	<b>37.49***</b> (11.10)
<i>Proceeds</i>	<b>-5.76***</b> (1.19)	<b>-5.75***</b> (1.21)	<b>0.37</b> (2.79)	<b>-1.98</b> (2.88)	<b>0.73</b> (3.74)
<i>Healthy at offering</i>	<b>-6.59**</b> (3.28)	<b>-6.95**</b> (3.35)	<b>18.66***</b> (6.91)	<b>27.09</b> (16.94)	<b>24.54**</b> (10.24)
<i>Capitalization at offering</i>	<b>4.34***</b> (1.44)	<b>4.38***</b> (1.41)	<b>-4.55</b> (3.35)	<b>-7.22</b> (5.31)	<b>-5.12</b> (4.29)
<i>Press coverage</i>	<b>-0.02***</b> (0.01)	<b>-0.02***</b> (0.01)	<b>-0.00</b> (0.01)	<b>-0.05</b> (0.05)	<b>-0.02**</b> (0.01)
<i>Relative quoted spread</i>	<b>-0.08*</b> (0.05)	<b>-0.08</b> (0.05)	<b>-0.06</b> (0.21)	<b>0.10</b> (0.22)	<b>0.45</b> (0.33)
<i>Market return at offering</i>	<b>1.43***</b> (0.24)	<b>1.42***</b> (0.23)			
<i>B/M</i>			<b>6.03</b> (6.03)	<b>3.17</b> (7.87)	<b>7.77</b> (6.46)
<i>Volatility</i>			<b>-2.15</b> (1.90)	<b>-6.46***</b> (1.60)	<b>0.73</b> (3.15)
Constant	<b>38.28***</b> (6.80)	<b>38.32***</b> (6.48)	<b>-16.78*</b> (9.65)	<b>28.70</b> (18.28)	<b>-23.50</b> (17.79)
<i>Number of observations</i>	103	103	95	95	95

**Table 3.9 : Stock liquidity of short sale constrained and unconstrained introductions**

This table presents the difference in liquidity between short sale constrained and unconstrained introductions on the second-stage offering day. Our sample includes 107 U.K. introductions that completed their second-stage offering between January 2002 and December 2013. We use the OLS regression as our estimation method:

$$Liquidity_i = \alpha_i + \beta_1 Security\ lending\ supply_i + \beta_2 Controls_i + \mu_i.$$

*Bid-ask spread* is the bid-ask spread on the second-stage offering day, measured in percentage. *Turnover* is calculated as trading volume divided by shares outstanding on the second-stage offering day. *Short sale unconstrained firm* is a dummy variable that equals one if the two-stage IPO firm is short sale unconstrained, and zero otherwise. *Security lending supply* is the total shares available for lending over total outstanding shares. *Capitalization at offering* is the natural log of firm size (measured in million pounds) at the second-stage offering. *Market return at offering* is the market index return from previous three months until the day before the second-stage offering day. *Market level at offering* is the market index level at the second-stage offering day. *Proceeds* is the natural log of the proceeds (measured in million pounds) at the second-stage offering. All columns include offering year dummy variables. Standard errors (reported in parentheses) are clustered by industry. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Variable	(1) Bid-ask spread	(2) Bid-ask spread	(3) Turnover	(4) Turnover
<i>Short sale unconstrained firm</i>	<b>-8.19</b> (5.64)		<b>0.76</b> (0.60)	
<i>Security lending supply</i>		<b>-0.18</b> (0.17)		<b>-0.00</b> (0.02)
<i>Capitalization at offering</i>	<b>24.54</b> (70.11)	<b>-0.15</b> (0.85)	<b>55.86</b> (50.31)	<b>-0.06</b> (0.21)
<i>Market return at offering</i>	<b>0.01*</b> (0.00)	<b>15.50</b> (88.55)	<b>0.00</b> (0.00)	<b>60.26</b> (50.44)
<i>Market level at offering</i>	<b>0.31</b> (0.35)	<b>0.00**</b> (0.00)	<b>0.15</b> (0.11)	<b>0.00</b> (0.00)
<i>Proceed</i>	<b>0.36</b> (1.02)	<b>0.30</b> (0.39)	<b>-0.12</b> (0.20)	<b>0.18</b> (0.10)
Constant	<b>-3.78</b> (11.76)	<b>-1.09</b> (9.51)	<b>-3.13</b> (3.48)	<b>-3.36</b> (3.65)
<i>Number of observations</i>	107	107	73	73
<i>R</i> <sup>2</sup>	0.14	0.12	0.52	0.51

## **Chapter 4**

### **Shorting on toxic arbitrage**

#### **4.1. Introduction**

Arbitrage plays an important role in financial markets. It benefits the market by enforcing the law of one price and enhancing the pricing efficiency (e.g., Roll, Schwartz, and Subrahmanyam, 2007; Gromb and Vayanos 2010). Yet limits to arbitrage make the short trade in an arbitrage strategy harder and more costly than the long trade (Hirshleifer, Teoh, and Yu, 2011). Therefore, a proper understanding of the short arbitrage and its impact on the market is crucial. In this paper, we employ a set of cross-listed stocks to identify arbitrage opportunities and show that in general, short arbitrageurs provide liquidity. However, they may also impair liquidity in cases of “toxic arbitrage” opportunities (i.e. arbitrage opportunities that arise because of asynchronous adjustments to news).

The previous literature examines the effects of arbitrage on market liquidity, and has mixed predictions: Holden (1995) and Gromb and Vayanos (2002, 2010) predict that arbitrageurs provide liquidity to the market when they correct the mispricing based on transient buying pressure. Foucault, Röell, and Sandås, (2003) conjecture that when arbitrageurs trade with asymmetric information, they impair market liquidity as dealers increase spreads to avoid being picked off by stale quotes. In addition, Foucault, Kozhan, and Tham (2015) posit that arbitrageurs have different effects on market liquidity depending on the source of arbitrage opportunities.

The literature on short selling finds mixed effects of short sales on market liquidity. Diether, Lee and Werner (2009) suggest that short sales provide liquidity to the market. Chakrabarty, Moulton, and Shkilko (2012) extend this argument by using order data to identify trade initiators, and find that both short sellers and long

sellers often act as liquidity providers. However, Shkilko, Van Ness, and Van Ness (2012) find that short sellers consume liquidity during intraday downward price pressures. In addition, Comerton-Forde, Jones, and Putniņš (2015) suggest that there are two types of short sales: liquidity supplying short sales and liquidity demanding short sales. They show that liquidity supplying short sales are contrarian, and usually trade when spreads are wide, while liquidity demanding short sales tend to follow short-term price drops and usually trade when spreads are narrow.

In this paper, we provide evidence on the heterogeneous effects of short sales on market liquidity based on arbitrage opportunities among Canadian stocks that are cross-listed in the U.S. market. A cross-listing arbitrage opportunity arises when prices in the U.S. and Canadian markets deviate from each other. Arbitrageurs simultaneously take a short position in the relatively overpriced market and a long position in the relatively underpriced market. We find that short arbitrageurs provide liquidity to the cross-listed stocks in general. However, short arbitrageurs could impair liquidity in cases of toxic relative to non-toxic arbitrage opportunities (i.e. arbitrage opportunities that arise because of liquidity shocks), and this liquidity impairment effect is stronger among firms with higher arbitrage costs.

To test the effects of short arbitrage on liquidity in different types of arbitrage opportunities, we obtain a sample of 134 Canadian stocks that are cross-listed in the U.S. market during the July 2006 and December 2013 period. The market for cross-listed stocks provides us with a novel setting in which we can clearly categorize arbitrage opportunities. In particular, this setting has the following advantages: first, the Canadian and U.S. markets share the same trading hours (i.e., 9:30 a.m. to 4:00 p.m. Eastern Time), which makes it easier to determine arbitrage opportunities. Second, Canadian stocks are cross-listed in the U.S. market as common stocks rather

than American depositary receipts (ADRs). These stocks have no conversion fee and no limits on cross-border ownership, implying that arbitrage is likely to occur frequently in the market of cross-listed stocks (Gagnon and Karolyi, 2010). Third, the U.S market has a large number of Canadian cross-listed firms, and these firms are relatively mature, which ensures a large and reliable set of arbitrage opportunities in our sample.

To provide a general assessment of short sellers' role in the market of cross-listed stocks, we examine the effect of short sales on Canadian stocks that are cross-listed in the U.S. market before identifying arbitrage opportunities. Consistent with the previous literature (Diether, Lee, and Werner 2009; Chakrabarty, Moulton, and Shkilko, 2012), we find that short sales provide liquidity to cross-listed stocks. In addition, short sales decrease both the price and return deviations between U.S. and Canadian markets. This finding supports the view that arbitrageurs enforce the law of one price and improve market efficiency (Bodie, Kane, and Marcus, 2009).

Next, we focus on cross-listing arbitrage opportunities with a short position in the U.S. market. We find that short sales provide liquidity where these arbitrage opportunities occur. Further, we categorize these arbitrage opportunities as toxic and non-toxic based on whether there is a fundamental change in the stock during the arbitrage opportunity. We find that short sales impair liquidity in cases of toxic relative to non-toxic arbitrage opportunities. This finding supports Foucault, Kozhan and Tham (2015) who conjecture that arbitrageurs provide liquidity in cases of non-toxic, but impair liquidity in toxic arbitrage opportunities.

Third, we examine toxic arbitrage opportunities among firms with high arbitrage costs, and find a stronger adverse effect of short sales on liquidity. This finding is consistent with the short restriction effect proposed by Diamond and Verrecchia

(1987), which posits that high short sale costs could drive out uninformed short sellers, which in turn would increase the information content in the short interest.

Our findings contribute to different strands of the asset pricing literature. First, we add to the limits to arbitrage literature by analyzing short sales in cases of toxic and non-toxic arbitrage opportunities. Since short arbitrage is harder and more costly than long arbitrage (Hirshleifer, Teoh, and Yu, 2011), it is worth testing how short sellers respond to different types of arbitrage opportunities, and how they influence the market. Using a novel sample of Canadian-U.S. cross-listing stocks, we directly test the effects of short arbitrage on stock liquidity. We show that short sales impair liquidity in cases of toxic relative to non-toxic arbitrages, and this impairment effect is stronger among firms with higher arbitrage costs.

Second, we add to the short selling literature by showing that short sales have heterogeneous impacts on the market liquidity in different scenarios (Comerton-Forde, Jones and Putniņš, 2015). We provide new evidence from the short arbitrage perspective. Our findings suggest that academics and market participants may examine short sales in different scenarios separately, as aggregating short sales could mask important features.

Third, we add to the cross-listing literature on the benefits of short arbitrage. Previous study that examines the relation between short sales and cross-listed firms (Gagnon and Witmer, 2014) mainly focuses on the 2008 short selling ban. Our evidence is more general, as we incorporate different types of arbitrage opportunities during a longer sample of seven years. We show that short sales enhance the law of one price and provide liquidity in the market of cross-listed firms.

The rest of our paper proceeds as follows: Section 2 develops hypotheses. Section 3 describes our sample construction and descriptive statistics. Section 4

presents empirical results. Section 5 presents the robustness test. Section 6 concludes.

## **4.2. Hypotheses development**

This section develops our hypotheses and presents the related literature. Our main research question focuses on the effects of short selling on liquidity in different arbitrage opportunities. Since in our study, we rely on the cross-listing setting to identify arbitrage opportunities, we conventionally start by analyzing the general effects of short sales on cross-listed stocks. Our first hypothesis posits that in general, short sales provide liquidity to cross-listed stocks and reduce the price-parity deviation between the home (i.e., Canadian) and U.S. markets.

Theory predicts that short sellers are better informed investors who provide liquidity to the market and help enhance the price discovery (e.g., Miller, 1977; Diamond, and Verrecchia, 1987; and Scheinkman and Xiong, 2003). Empirical evidence from U.S. local stocks supports this prediction (e.g., Diether, Lee, and Werner 2009; Chakrabarty, Moulton, and Shkilko, 2012). In addition, by studying cross-listed stocks during the 2008 short selling ban, Gagnon and Witmer (2014) find that cross-listed stocks subject to the ban experience an increase in bid-ask spread in the U.S. market. They show that the ownership for U.S cross-listed Canadian stocks is tilted heavily towards Canadian investors, while long sellers are relatively scarcer in the U.S. market.<sup>16</sup> Their findings imply that market-makers may rely heavily on short sales to provide liquidity for cross-listed stocks in the U.S. market.

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<sup>16</sup> They show that for cross-listed financial stocks, more than 80% of the shares held by U.S. and Canadian investors combined are owned by Canadian investors.

Collectively, we conjecture that the general liquidity provision effect of short sales also applies to cross-listed stocks. In addition, as short sales enhance the price discovery, they should enforce the law of one price in both markets of cross-listed firms. Overall, our first hypothesis states:

*H1: Short sales of cross-listed stocks enhance the U.S. market liquidity (H1a) and reduce price-parity deviations between the home and U.S. markets (H1b).*

Previous literature shows that the effects of arbitrageurs on liquidity depend on the cause of the arbitrage opportunities. On the one hand, theory predicts that short sales provide liquidity to the market when the arbitrage opportunity arises from liquidity shocks (e.g., Grossman and Miller, 1988; Campbell, Grossman, and Wang, 1993, and Gromb and Vayanos, 2010). Empirically, Comerton-Forde, Jones and Putniņš (2015) find that short sales provide liquidity to the market when spreads are unusually wide, normally after sharp rises in price. However, they do not consider arbitrage opportunities.

On the other hand, Foucault, Kozhan, and Tham (2015) predict that if an arbitrage opportunity arises from information asymmetry, the arbitrage could be toxic because arbitrageurs may response faster than domestic dealers, increase the adverse selection costs, and impair liquidity. Empirically, Shkilko, Van Ness, and Van Ness (2012) find that short sellers consume liquidity during intraday downward price pressures, but they claim that the price decline is not related to events or asymmetric information. So far, the liquidity impairment effect of short sales in cases of toxic arbitrage opportunities has not been empirically tested.

Further, since short sales only represent the sell side of a cross-listing arbitrage strategy, their impairment effect on liquidity should be stronger in cases of toxic arbitrage with bad news. To summarize, our second hypothesis posits:



*H2: Short sales provide liquidity to the U.S. market in cases of cross-listing arbitrage opportunities (H2a), but impair liquidity in toxic relative to non-toxic arbitrage opportunities (H2b). This liquidity impairment effect is stronger in cases of toxic arbitrage opportunities with bad news (H2c).*

Previous literature shows that arbitrage costs could deter arbitrage activities (Gromb and Vayanos, 2010). Empirically, Au, Doukas, and Onayev (2009) and Duan, Hu, and McLean (2010) find that idiosyncratic risk, as a type of arbitrage holding costs, deters short selling. They show that short sales in stocks with higher idiosyncratic risk have stronger predictive power on future stock price decline.

Further, Diamond and Verrecchia (1987) predict that increasing arbitrage costs may have a short restriction effect: high arbitrage costs drive out uninformed short sellers and increase the information content in short interests. Empirically, Kolasinski, Reed, and Thornock (2013) support this prediction, and show that the 2008 short selling ban increases short selling costs and improves the ratio of informed to uninformed short sellers in the U.S. market. Based on the short restriction effect prediction, we expect the proportion of informed short sellers to be higher in stocks with high arbitrage costs. This would worsen the adverse selection problem in cases of toxic arbitrage opportunities and further impair liquidity. To summarize, our third hypothesis posits:

*H3: The impairment effect of short sales on liquidity in cases of toxic arbitrage opportunities (H2b and H2c) is stronger for firms with higher arbitrage costs.*

### **4.3. Sample construction and descriptive statistics**

#### **4.3.1. Sample construction**

Our sample comprises a set of Canadian stocks which are simultaneously traded on the Toronto Stock Exchange (TSX) and one of the main U.S. exchanges (i.e.,

NYSE, NASDAQ, or AMEX) between July 2006 and December 2013. We construct our sample as follows: First, we use information in DataStream to identify all Canadian ordinary stocks that are cross-listed in the U.S. market during the sample period. Next, to ensure the feasibility of cross-listing arbitrage, we exclude financial stocks and stocks that are traded over-the-counter. Further, we require stocks to have (i) home-market counterpart data available in DataStream or Compustat Global and (ii) U.S. securities lending data in Markit Securities Finance Data. After applying these filters, we end up with 134 Canadian-U.S. pairs.

We obtain daily stock closing price, trading volume, shares outstanding and dividend payments for each stock-pair from Compustat Global and DataStream, S&P500 index, S&P/TSX index and VIX from DataStream, intraday bid and ask quotes for U.S. stocks from the NYSE Trade and Quote database (TAQ), and intraday bid and ask quotes for Canadian stocks from Thomson Reuters Tick History (TRTH). Further, to convert home-market price into U.S. dollars, we also obtain the intraday quotes of the currency pair CAD/USD from TRTH. We obtain daily securities lending quantity and value-weighted lending fee for each stock-pair from Markit Securities Finance Data.

#### **4.3.2. Arbitrage opportunities**

A cross-listing arbitrage strategy includes taking a long position in the relatively undervalued part of the stock-pair and opening a short position in the overvalued part (De Jong, Rosenthal, and Van Dijk, 2009). In this study, we mainly focus on the short side of the cross-listing arbitrage strategy. Following Gagnon and Karolyi (2010), we measure price-parity deviations using the log price difference, i.e., the log difference between the price in the U.S. market ( $P_{i,t}^{US}$ ) and that in the Canadian

market expressed in USD ( $P_{i,t}^{CA}$ ). To identify a cross-listing arbitrage opportunity of stock-pair  $i$  on day  $t$ , we first estimate the historical mean (i.e.,  $\overline{\ln(P^{US}/P^{CA})_{i,t}}$ ) and volatility (i.e.,  $\sigma_{i,t}$ ) of  $i$ 's log-price difference over one year preceding day  $t$ .<sup>17</sup> Motivated by Shkilko, Van Ness, and Van Ness (2012), we define day  $t$  as an arbitrage day for U.S. short sellers if the log-price difference for stock  $i$  exceeds its historical mean by two or more standard deviations. In this case, arbitrageurs would take a short position in the U.S. market, since the U.S. price of stock  $i$  is overvalued relative to its Canadian price. We denote this type of arbitrage opportunities as  $Short^{US}$  arbitrage. Similarly, if the log-price difference of stock  $i$  is two or more standard deviations below its historical mean, the Canadian price is overvalued relative to the U.S. stock on day  $t$ . Arbitrageurs would take a short position in the Canadian market. We denote this type of arbitrage opportunities as  $Short^{CA}$  arbitrage.

To further distinguish toxic arbitrage from non-toxic arbitrage opportunities, for each stock-pair, we calculate the average price of the pair (i.e.,  $P^{US}$  and  $P^{CA}$ ) on a daily basis for both the pre-arbitrage (i.e., [-5, -1]) and post-arbitrage (i.e., [+1, +5]) windows. We then compare the average prices for this stock-pair between these two windows using a Wilcoxon rank-sum test. If the arbitrage opportunity arises from a liquidity shock in one market, then the price in that market would converge back to its fundamental value when buying pressure subsides (e.g., Grossman and Miller, 1988; Campbell, Grossman, and Wang, 1993). In this case, the post-arbitrage average stock price should remain similar to the pre-arbitrage average price. In contrast, if the arbitrage opportunity arises from asynchronous price adjustments to news, then the average prices in the post-arbitrage window could be significantly different from the pre-arbitrage average prices, as the new prices reflect a new

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<sup>17</sup> Our results remain similar if we change this estimation period into half year preceding day  $t$ .

fundamental value. We define an arbitrage opportunity as toxic if the post-arbitrage average price is statistically different from the pre-arbitrage average.<sup>18</sup> Further, among toxic arbitrage opportunities, we define those with post-arbitrage average prices being significantly lower (higher) than pre-arbitrage average prices as *toxic<sup>down</sup>* (*toxic<sup>up</sup>*) arbitrage opportunities.

Table 4.1 provides the characteristics of arbitrage events. Among all *Short<sup>US</sup>* arbitrage opportunities, non-toxic arbitrages account for 72%, while toxic arbitrage accounts for the remaining 28%. The average duration for a typical arbitrage opportunity is one day, which indicates that arbitrageurs are active in exploiting price-parity deviations. The average arbitrage profit ( $|Ln(P^{US}/P^{CA})|$ ) is around 2% per day, much larger than the sum of expected transaction costs and holding costs.<sup>19</sup> Therefore, cross-listing arbitrage is feasible in our sample.

The profits for *Short<sup>US</sup>* toxic and non-toxic arbitrage opportunities are similar (2.06 percent vs. 2.09 percent,  $t=0.72$ ). Further, among *Short<sup>US</sup>* toxic arbitrage opportunities, *toxic<sup>down</sup>* arbitrages have significantly higher profit (2.23%) than that of *toxic<sup>up</sup>* arbitrages (2.09%,  $t=4.51$ ). We also report the absolute log return difference between the U.S. and Canadian market ( $|Ln(R^{US}/R^{CA})|$ ) as an alternative measure of price-parity deviation. The statistics of the log return difference are similar to that for absolute log price difference.

#### 4.3.3. Summary statistics

Table 4.2 presents the summary statistics of our sample. We winsorize variables at the 1<sup>st</sup> and 99<sup>th</sup> percentiles to mitigate the effects of outliers. We define *short*

<sup>18</sup> We require the Wilcoxon rank-sum test of price differences to be significant at the 1% level.

<sup>19</sup> According to trading costs published by Elkins and McSherry, the average transaction cost including commissions, taxes, fees and market impact costs is 17.64 bps in the U.S. and 25.42 bps in Canada at the end of 2012. The average daily lending fee of our sample during *Short<sup>US</sup>* arbitrage opportunities is 0.63 bps daily.

*interest*, the main proxy for short selling, as the daily quantity of shares borrowed, normalized by total outstanding shares for each firm. Liquidity measures include: (i) *percent quoted spread*, which is calculated as the difference between the best bid and ask prices divided by the midpoint of the two. This variable is estimated at intraday level and is then time-weighted into daily frequency. (ii) *Amihud illiquidity*, which is measured as the absolute daily percentage return divided by the daily dollar trading volume (Amihud, 2002).

In general, the U.S. market is less liquid, and has lower short interest on days with arbitrage opportunities. Specifically, among three types of  $Short^{US}$  arbitrage opportunities (i.e.,  $toxic^{up}$ ,  $toxic^{down}$ , and non-toxic),  $toxic^{down}$  has the greatest short interest (3.44 bps) and largest *percent quoted spread* (58.65 bps). In contrast,  $toxic^{up}$  and non-toxic arbitrage opportunities have similar short interest (2.80 bps vs. 2.92 bps,  $t=0.35$ ) while  $toxic^{up}$  has lower *percent quoted spread* (46.60 bps vs. 52.21 bps,  $t=1.75$ ). Further, *Amihud illiquidity* is not statistically different among the three types of  $Short^{US}$  arbitrage opportunities.

Table 4.3 reports the correlations of the main variables. Consistent with *H1a*, short interest in the U.S. market is negatively correlated with the *percent quoted spread* and *Amihud illiquidity*, indicating that short selling enhances liquidity for cross-listed stocks. Further, short interest is negatively correlated with Canadian-U.S. price deviation, as well as return difference, which is consistent with *H1b*.

In addition, both dummy variables,  $Short^{US}$  and  $Short^{CA}$ , are positively correlated with U.S. *percent quoted spread* and *Amihud illiquidity*. This evidence suggests that liquidity is lower on days with arbitrage opportunities. These relations are also consistent with our findings in the summary statistics.

Moreover, we show that liquidity in the U.S. market decreases with arbitrage costs. Specifically, we use lending fee and idiosyncratic volatility to measure arbitrage costs. We define lending fee as the value-weighted lending fee over the previous seven days for each stock. Following Gagnon and Karolyi (2010), we estimate idiosyncratic volatility by regressing the daily Canadian-U.S. return difference over the previous three months, on leading, contemporaneous, and lagged daily U.S. market index, Canadian index returns, and foreign exchange changes. We use the standard deviation of residuals as the proxy for cross-listing arbitrage costs. We find that both arbitrage cost measures are positively correlated with Canadian-U.S. absolute price and return differences. This finding is consistent with the notion that arbitrage costs deter arbitrage activity (Gromb and Vayanos, 2010).

#### 4.4. Empirical results

##### 4.4.1. The effect of short sales on liquidity and price-parity deviation of cross-listed firms

In this section, we test whether short sales in the U.S. market provide liquidity to the cross-listed stocks (*H1a*) and reduce the price-parity deviations (*H1b*). In particular, we estimate the following regression to test *H1a*:

$$Liquidity_{i,t} = \alpha_{i,t} + \beta_1 Short\ interest_{i,t} + \beta_2 Controls_{i,t} + \mu_{i,t}. \quad (4)$$

Liquidity measures include *percent quoted spread* and *Amihud illiquidity* for the U.S. market. Control variables include the following factors that are known to influence stock liquidity: *Capitalization* is the firm size measured in million pounds. *Dollar volume* is the daily dollar trading volume measured in million pounds. *1/Price* is the reciprocal of share price. *Volatility* is the standard deviation of daily stock returns over the previous month. U.S. index is the index level of S&P500. *Ban* is a dummy variable that equals to one during the short selling ban period between

19 September 2008 and 8 October 2008, and zero otherwise. We also include firm fixed effects and year dummies.

Panel A of Table 4.4 presents the estimation results. Columns (1) and (2) show that short interest is negatively associated with *percent quoted spread*. In economic terms, a one standard deviation (i.e., 0.08%) increase in short interest in the U.S. market would reduce the *percent quoted spread* by 0.9 basis point after controlling for factors that are known to affect liquidity. Results are similar if we use Amihud illiquidity as an alternative liquidity measure, as reported in Columns (3) and (4). Economically, after including all control variables, a one standard deviation increase in short interest could be associated with a 0.25 percent decrease in Amihud illiquidity.<sup>20</sup> Collectively, these results support our *H1a* that in general, short sellers provide liquidity to cross-listed stocks.

Next, to examine whether short sales reduce the cross-listing price-parity deviation (*H1b*), we estimate the following regression:

$$\begin{aligned} \text{Price parity deviation}_{i,t} = & \alpha_{i,t} + \beta_1 \text{Short interest}_{i,t} + \beta_2 \text{Controls}_{i,t} \\ & + \mu_{i,t}. \end{aligned} \quad (5)$$

Following Gagnon and Karolyi (2010), we measure the price-parity deviation with the absolute log difference of both prices and returns between the U.S. and Canadian markets.<sup>21</sup> we include a set of firm-specific proxies as well as market condition proxies that are known to explain the price-parity deviation. Firm-specific proxies are as follows: *Volatility*, *capitalization* and *dividend yield* for each stock in

<sup>20</sup> To interpret the coefficients, one should note that the short interest and *Amihud illiquidity* are measured in percentage while the quoted spread is measured in basis point in all the regressions.

<sup>21</sup> Our results remain similar if we use log difference of prices/returns between the U.S. and Canadian markets. In unreported tests, we split our sample into two based on the sign of log difference of prices/returns between the U.S. and Canadian markets. We find that when the sign is positive (i.e., when the price is higher in the U.S. relative to that in Canada), the U.S. short interest is significantly negatively correlated with log price/return difference; when the sign is negative (i.e., when the price is higher in Canada relative to that in the U.S.), the correlation between the U.S. short interest and log prices/returns is insignificant.

the U.S. and Canadian markets. We also include *turnover* in the U.S. and Canadian markets as an additional firm-specific proxy, which is defined as the number of traded shares divided by total shares outstanding for each country.

In addition, market condition proxies include the U.S. (i.e., S&P 500) and Canadian (i.e., S&P/TSX) *market indexes*, index return volatilities over the previous month for both the U.S. (*VIX*) and Canada (*CA index volatility*), USD/CAD exchange rate volatility over the previous month (*FX volatility*) and *ban*. We also include lagged absolute price and return log differences between the U.S. and Canadian markets to control for potential autocorrelation in our dependent variables.

Panel B of Tables 4.4 presents regression estimates for *H1b*. We find that short interest in the U.S. market is negatively correlated with both the log absolute price and log return differences between the U.S. and Canadian markets. In economic terms, a one standard deviation increase in the short interest is associated with a decrease of 81 basis points in both the log absolute price and log return differences. This evidence indicates that short selling in the U.S. market enhances pricing efficiency by reducing the price-parity deviation among cross-listed stocks. Based on the above findings, we conjecture that short sellers play a similar role in the cross-listing market as they do in the conventional market. Therefore, our following analysis on short arbitrage is less likely to be restricted to any specific feature of the cross-listing setting.

#### **4.4.2. The effect of short sales on liquidity: toxic versus non-toxic arbitrage opportunities**

In this section, we test whether short sales in the U.S. market enhance market liquidity in cases of cross-listing arbitrage opportunities (*H2a*), and impair liquidity



in toxic relative to non-toxic arbitrage opportunities (*H2b*). We further examine whether the liquidity impairment effect of short sales is driven by short sales in cases of *toxic<sup>down</sup>* arbitrage opportunities (*H2c*). Since we focus on short sales of cross-listed stocks in the U.S. market, we mainly examine *Short<sup>US</sup>* arbitrage opportunities in the rest of our analyses. We limit our sample to  $\pm 5$  days around each *Short<sup>US</sup>* event day to mitigate the potential influences on liquidity from non-arbitrage events and *Short<sup>CA</sup>* arbitrage opportunities. Further, we exclude dividend record days to avoid the contamination from dividend arbitrage events. For robustness, we also report the full sample estimation results in the robustness test section.

To test *H2*, we include a set of dummy variables into Equation (4) to determine the effects of short sale on liquidity in different types of arbitrage opportunities. Specifically, the set of dummy variables includes: (i) *Short<sup>US</sup>*, which equals one if the short side of an arbitrage is initiated in the U.S., and zero otherwise; (ii) *toxic*, which equals one if the arbitrage opportunity arises from asynchronous price adjustments to fundamental changes, and zero otherwise; (iii) *toxic<sup>up</sup>*, which equals one if the fundamental change of the stock pair is positive, and zero otherwise; and (iv) *toxic<sup>down</sup>*, which equals one if the fundamental change of the stock pair is negative, and zero otherwise.

Panel A of Table 4.5 reports estimation results with *percent quoted spread* as the dependent variable. Specifically, Columns (1) and (2) present the effect of short interest on liquidity in *Short<sup>US</sup>* arbitrage opportunity. The coefficients of short interest are negative in both columns (i.e., -12.16 and -8.5243, respectively), which suggests that short sales provide liquidity to the U.S. market during non-arbitrage days in our sample. Further, we find that liquidity promoting effect of short sales is stronger in *Short<sup>US</sup>* arbitrage opportunities. The coefficients of the interaction

between the short interest and the  $Short^{US}$  are -21.25 and -16.79, respectively. These findings are consistent with *H2a* and show that short sales provide liquidity in cross-listing arbitrage opportunities.

Columns (3) and (4) present the effects of short sales on liquidity in cases of toxic  $Short^{US}$  arbitrage opportunities. The coefficients of the interaction between short interest and  $Short^{US}$  are -20.73 and -16.29, respectively. This finding indicates that short sales provide more liquidity to the market in cases of non-toxic  $Short^{US}$  arbitrage opportunities. In cases of toxic  $Short^{US}$  arbitrage opportunities, short sales still provide liquidity to the market.<sup>22</sup> This is expected since long sellers of cross-listed Canadian stocks are relatively scarce in the U.S. market. Consequently, the U.S. market relies heavily on short sellers to provide liquidity to these cross-listed stocks. However, coefficients of the interaction of short interest,  $Short^{US}$ , and toxic are positive in Columns (3) and (4) (i.e., 52.12 and 48.63), which suggests that the liquidity promoting effect of short sales in cases of toxic arbitrage opportunities is weaker than that in non-toxic arbitrage opportunities. This evidence supports *H2b* and shows that short sales increase the adverse selection cost and relatively impair liquidity in cases of toxic arbitrage compared to non-toxic arbitrage opportunities.

Further, the coefficients associated with the interaction of  $Short^{US}$ , short interest, and  $toxic^{down}$  are positive in Columns (5) and (6) (66.78 and 61.01), which indicates that the liquidity promoting effect of short sales is weaker in cases of  $toxic^{down}$  arbitrage opportunities when compared to non-toxic ones. The coefficients of interaction variable  $Short^{US}$ , short interest, and  $toxic^{up}$  is insignificant in Columns (5) and (6). This evidence is consistent with *H2c* and suggests that the liquidity

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<sup>22</sup> The net effect of short sales on U.S. percent quoted spread in cases of toxic arbitrage opportunities equals to the sum of coefficients of U.S. short interest (-11.50),  $Short^{US} \times U.S. short interest$  (-20.73),  $Toxic \times U.S. short interest$  (-55.98) and  $Toxic \times Short^{US} \times U.S. short interest$  (52.12), which equals to -36.09.

impairment effect of short sales is mainly driven by short sales in cases of toxic arbitrage opportunities with bad news.

Our estimation results remain similar when we use Amihud illiquidity as an alternative liquidity measure, as reported in Panel B of Table 4.5.

#### 4.4.3. The effect of short sales on liquidity: arbitrage costs

In this section, we test whether higher arbitrage costs deteriorate the liquidity impairing effect of short sales in cases of toxic, and especially  $toxic^{down}$  arbitrage opportunities ( $H3$ ). We use lending fee as our main proxy for arbitrage costs. In particular, *high lending fee* is a dummy variable that equals to one if the stock belongs to the top lending fee decile on day  $t$ , and zero otherwise. For robustness, we also report results with idiosyncratic volatility as an alternative arbitrage cost measure. *High idiosyncratic volatility* is a dummy variable that equals to one if the stock belongs to the top idiosyncratic volatility decile on day  $t$ . We interact these two dummy variables with factors in the regressions for  $H2$ .

Panel A of Table 4.6 presents the estimation results with high lending fee as the high arbitrage costs indicator. The coefficients associated with the interaction of  $Short^{US}$ , short interest, and toxic are positive but insignificant regardless of liquidity measures. The coefficients of the interaction of high lending fee,  $Short^{US}$ , short interest and toxic are significantly positive by using both *percent quoted spread* and *Amihud illiquidity* as the liquidity measures. The results suggest that the liquidity impairment effect of short sales is stronger for firms with high arbitrage costs in cases of toxic arbitrage opportunities.

Next, we split toxic arbitrage opportunities into two groups:  $toxic^{up}$  and  $toxic^{down}$ . The variable of interest is the interaction of high lending fee,  $Short^{US}$ , short interest,

and  $toxic^{down}$ . We find that the coefficients of the interaction term are significantly positive for both liquidity measures (i.e., Columns (3) and (4) for *percent quoted spread*, and Columns (7) and (8) for *Amihud illiquidity*). In contrast, all coefficients of interaction terms associated with  $toxic^{up}$  are statistically insignificant. Our results remain similar when we use high idiosyncratic volatility as the proxy for high arbitrage costs, as reported in Panel B of Table 4.6. Overall, these findings support *H3*, namely that the adverse effect of short sales on liquidity in cases of toxic arbitrages is stronger for firms with higher arbitrage costs.

#### **4.4.4. Matching portfolios**

Thus far, we have found that short selling provides liquidity for stocks that are cross-listed in the U.S. market. Arbitrage motivated short sales enhance liquidity in cases of non-toxic arbitrages but impair liquidity in toxic, especially  $toxic^{down}$  arbitrage opportunities. The liquidity impairment effect of short sales in cases of toxic arbitrage opportunities is stronger among firms with higher arbitrage costs. In this section, we provide additional evidence by benchmarking each cross-listed stock against a matching portfolio. The differences between treatment firms and control portfolios enable us to examine whether liquidity, short interest and lending fee for cross-listed firms are abnormal in arbitrage opportunities. According to Davies and Kim (2009), matching with a control portfolio could be optimal when results are sensitive to the particular choice of one stock as the control firm. Since short interest, by nature, could vary significantly among stocks with similar size and price, a portfolio control would be more reliable in our test.

To form matching portfolios, we first construct size and price deciles independently with all U.S. ordinary stocks that are traded during our sample period.

We then create intersections of the size and price deciles. The corresponding portfolio for each cross-listed stock is used as the control portfolio. We define *abnormal short interest* (*abnormal percent quoted spread*) (*abnormal Amihud illiquidity*) (*abnormal lending fee*) as the *short interest* (*percent quoted spread*) (*Amihud illiquidity*) (*lending fee*) of the treatment firm minus the equal-weighted average *short interest* (*percent quoted spread*) (*Amihud illiquidity*) (*lending fee*) of the matching portfolio. Further, we rank cross-listed firms by abnormal lending fee on each trading day, and use the dummy variable high abnormal lending fee to identify firms with high abnormal lending fee on a daily basis. Specifically, the dummy variable equals to one if a firm belongs to the top abnormal lending fee decile, and zero otherwise.

Panel A of Table 4.7 reports the estimation results when *abnormal percent quoted spread* is used as the dependent variable. In Column (1), the coefficient of abnormal short interest is -82.70. Economically, a one standard deviation (0.13%) increase in abnormal short interest would reduce the *abnormal percent quoted spread* by 10.75 basis points. This finding is consistent with *H1a*, namely that short selling enhances liquidity for cross-listed stocks in the U.S. In Column (2), the coefficient associated with the interaction between  $Short^{US}$  and abnormal short interest is negative, indicating that short sales provide more liquidity to the U.S. market in cases of  $Short^{US}$  arbitrage opportunities (i.e., *H2a*). Columns (3) and (4) show that short sales provide less liquidity in cases of toxic, especially  $toxic^{down}$  arbitrage than in non-toxic arbitrage opportunities, which suggests that the effects of short sales on liquidity are heterogeneous. Further, Columns (5) and (6) report estimation results for *H3*. Column (5) shows that the coefficient of the interaction of high abnormal lending fee,  $Short^{US}$ , toxic, and abnormal short interest is significantly

positive. This result supports *H3* by showing that the liquidity impairment effect of short sales in cases of toxic arbitrage opportunities is stronger among firms with higher arbitrage costs. However, in Column (6), the coefficient of the interaction of high abnormal lending fee,  $Short^{US}$ ,  $toxic^{down}$ , and abnormal short interest is insignificant.

#### 4.4.5. Robustness tests

##### 4.4.5.1. Endogeneity Concerns

In the previous section, our estimations do not address the potential endogeneity between the short selling and liquidity measures. For example, short sellers would trade more actively when the liquidity is high. Further, some omitted variables could be correlated with short sales while also affect stock liquidity. In this section, we employ the two-stage ordinary least square (2SLS) estimation, using lagged U.S. short interest, lagged change in U.S. lending fee, and their interaction terms with our set of key dummy variables (e.g.,  $Short^{US}$ ,  $Toxic$ ,  $Toxic^{up}$ ,  $Toxic^{down}$ , and *High abnormal lending fee*) as instrumental variables to account for the endogeneity concern.

The second-stage estimation results of the 2SLS approach are reported in Table 4.8. In Panel A, the liquidity measure is *U.S. percent quoted spread*. The 2SLS estimation results are similar as our main results in Tables 4.5 and 4.6. Specifically, Column (1) shows that short sellers in the U.S. provide liquidity to the U.S. market in  $Short^{US}$  arbitrage opportunities, which is consistent with *H2a*. Column (2) supports *H2b* and shows that short sellers in the U.S. provide less liquidity in toxic  $Short^{US}$  arbitrage opportunities relative to non-toxic ones. In addition, Column (3) supports *H2c* and shows that short sellers provide less liquidity in  $toxic^{down} Short^{US}$

arbitrage opportunities. The result in Column (4) is insignificant. However, in Column (5), we find that the short sellers provide less liquidity for firms with high lending fees in cases of  $toxic^{down} Short^{US}$  arbitrage opportunities. This finding suggests that the liquidity impairment effect in cases of  $toxic^{down} Short^{US}$  arbitrage opportunities is stronger for firms with high arbitrage costs, which is consistent with  $H3$ . The Anderson-Rubin Wald statistics and Hansen's J-statistic suggest that our instrumental variables are relevant and valid in all of the regressions.

Panel B uses *U.S. Amihud illiquidity* as liquidity measure. Results are similar to those in Panel A. Overall, our main results remain consistent after using the instrumental variable estimation to account for potential endogeneity problem.

#### 4.4.5.2. Full sample estimation

In our main tests for  $H2$  and  $H3$ , we limit our sample to  $\pm 5$  days around each  $Short^{US}$  event to avoid contamination from other events. In the robustness test, we check the sensibility of our results to the choice of sample. We estimate similar regressions as those in Tables 4.5 and 4.6 with full time-series. Specifically, we add dummy variable  $Short^{CA}$  and the interaction term between U.S. short interest and  $Short^{CA}$  to each regression to account for the effect of  $Short^{CA}$  arbitrage opportunities.

Table 4.9 presents the results of full time series estimation. We find that results remain similar to those reported in Tables 4.5 and 4.6, regardless of the choice of liquidity measures. Overall, our main results for  $H2$  and  $H3$  are robust with the full time series estimation.

#### **4.5. Conclusion**

In this study, we take a fine categorization of cross-listing arbitrage opportunities and examine the effects of short sales on market liquidity in different scenarios. Cross-listing arbitrage arises when the U.S. price and home-market price deviate from each other. It could be toxic if this arbitrage opportunity arises as a result of asynchronous price adjustments to news, because informed short sellers may increase adverse selection costs for liquidity providers. Our analysis indicates that short sales reduce price-parity deviations and provide liquidity to the U.S. market for cross-listed stocks, especially in cases of arbitrage opportunities. However, they impair liquidity in cases of toxic relative to non-toxic arbitrage opportunities, and this liquidity impairment effect is stronger among firms with higher arbitrage costs.

These empirical findings support the view that academics and market participants should not view short sellers as monolithic (Comerton-Forde, Jones and Putniņš, 2015). There could be different types of short sales and short sales could have different effects on market liquidity depending on market conditions and trading strategies. Therefore, it is worth making categorizations for both short sale transactions and arbitrage opportunities in the future research.

In addition, we find that the liquidity impairment effect of short sales in cases of toxic arbitrage opportunities does not negate the general benefits from short selling activities. In general, short sales provide liquidity to the market. Short sales also help to enhance the law of one price for cross-listed stocks. Our findings suggest that short selling is an important component in the cross-listing market to promote liquidity and pricing efficiency. Regulators may consider short sales as heterogeneous trading rather than condemn them in blanket fashion.



**Table 4.1 : Arbitrage profits and durations**

This table presents the profits and durations for each type of arbitrage opportunities. Our sample includes 134 Canadian stocks that are cross-listed in the U.S. between July 2006 and December 2013. We define  $|Ln(P^{US}/P^{CA})|$  as the absolute log difference between the price in the U.S. and the price in Canada expressed in USD.  $|Ln(R^{US}/R^{CA})|$  is the absolute log difference between the return in the U.S. and the return in Canada. Duration is the number of days that an arbitrage opportunity persists.

	N	25%	Median	Mean	75%	Std. Dev.
<i>Short<sup>US</sup> (Pooled)</i>						
$ Ln(P^{US}/P^{CA}) $	3,389	1.00	1.82	2.08	3.06	1.18
$ Ln(R^{US}/R^{CA}) $	3,389	0.90	1.64	2.10	2.98	1.53
<i>Duration</i>	3,389	1.00	1.00	1.09	1.00	0.49
<i>Short<sup>US</sup> (Toxic)</i>						
$ Ln(P^{US}/P^{CA}) $	935	0.97	1.78	2.06	3.01	1.18
$ Ln(R^{US}/R^{CA}) $	935	0.86	1.60	2.04	2.91	1.53
<i>Duration</i>	935	1.00	1.00	1.19	1.00	0.79
<i>Short<sup>US</sup> (Toxic<sup>down</sup>)</i>						
$ Ln(P^{US}/P^{CA}) $	463	1.22	2.01	2.23	3.28	1.17
$ Ln(R^{US}/R^{CA}) $	463	1.04	1.75	2.20	3.08	1.52
<i>Duration</i>	463	1.00	1.00	1.29	1.00	1.06
<i>Short<sup>US</sup> (Toxic<sup>up</sup>)</i>						
$ Ln(P^{US}/P^{CA}) $	472	0.89	1.50	1.89	2.67	1.17
$ Ln(R^{US}/R^{CA}) $	472	0.74	1.34	1.89	2.63	1.53
<i>Duration</i>	472	1.00	1.00	1.08	1.00	0.34
<i>Short<sup>US</sup> (Non-toxic)</i>						
$ Ln(P^{US}/P^{CA}) $	2,454	1.01	1.84	2.09	3.07	1.18
$ Ln(R^{US}/R^{CA}) $	2,454	0.92	1.66	2.12	3.01	1.53
<i>Duration</i>	2,454	1.00	1.00	1.06	1.00	0.29
<i>Short<sup>CA</sup> (Pooled)</i>						
$ Ln(P^{US}/P^{CA}) $	3,216	0.99	1.60	1.94	2.72	1.14
$ Ln(R^{US}/R^{CA}) $	3,216	0.85	1.51	2.00	2.78	1.50
<i>Duration</i>	3,216	1.00	1.00	1.48	1.00	2.76

**Table 4.2 : Summary statistics**

This table presents summary statistics for the full sample as well as each type of arbitrage opportunities. Our sample includes 134 Canadian stocks that are cross-listed in the U.S. between July 2006 and December 2013. *Short interest* is the daily quantity of shares borrowed, normalized by total outstanding shares for each firm *Percent quoted spread* is the difference between the best bid and best ask divided by the midpoint of them, aggregated into daily frequency. *Amihud illiquidity* is the absolute daily percentage return divided by the daily dollar trading volume. *Idiosyncratic volatility* is the standard deviation of the residual of the daily Canadian-U.S. return differences over the previous three months regressed the on leading, contemporaneous, and lagged daily U.S. market index, Canadian index returns, and foreign exchange rate changes. *Capitalization* is the firm size measured in million pounds. *Dollar volume* is the daily dollar trading volume measured in million pounds. *1/Price* is the inverse of share price. *Volatility* is the standard deviation of daily stock returns over the previous month. *U.S. index* is the S&P500 index level. *CA index* is the level of the S&P/TSX index. *VIX* is the U.S. market volatility index. *CA index volatility* is the S&P/TSX index volatility over the previous month for Canada. *FX volatility* is the USD/CAD exchange rate volatility over the previous month.

	N	25%	Median	Mean	75%	Std. Dev.
<i>Full Sample</i>						
<i>U.S. short interest (bps)</i>	130,155	0.00	0.33	3.22	2.31	8.10
<i>U.S. percent quoted spread (bps)</i>	130,155	7.91	18.47	35.95	45.18	47.45
<i>U.S. Amihud illiquidity</i>	129,975	0.05	0.31	5.91	2.59	19.18
<i>Idiosyncratic volatility (%)</i>	130,155	0.46	0.77	1.03	1.27	0.88
<i>U.S. lending fee (bps)</i>	113,822	10.00	16.17	137.35	94.47	333.92
<i>U.S. dollar volume (\$ Millions)</i>	130,155	0.64	4.13	20.37	19.64	40.44
<i>Capitalization (\$ Millions)</i>	130,155	5.89	7.12	7.28	8.75	1.75
<i>U.S. index level</i>	130,155	1,197.30	1,342.84	1,332.26	1,461.89	221.24
<i>CA index level</i>	130,155	1,504.10	1,570.10	1,573.15	1,678.77	148.97
<i>VIX</i>	130,155	15.02	18.47	21.17	24.29	9.45
<i>CA index volatility</i>	130,155	15.96	22.65	25.33	31.45	13.19
<i>U.S. 1/Price</i>	130,155	0.04	0.10	0.18	0.26	0.19
<i>U.S. volatility</i>	130,155	0.21	0.43	0.65	0.85	0.64
<i>CA volatility</i>	129,345	0.20	0.41	0.61	0.80	0.60
<i>Short<sup>US</sup> (Pooled)</i>						
<i>U.S. short interest (bps)</i>	3,389	0.00	0.25	2.97	2.05	7.55
<i>U.S. percent quoted spread (bps)</i>	3,389	10.06	27.40	52.31	67.79	65.13
<i>U.S. Amihud illiquidity</i>	3,379	0.07	0.56	9.81	5.08	26.06
<i>Idiosyncratic volatility (%)</i>	3,389	0.54	1.01	1.25	1.59	0.98
<i>U.S. lending fee (bps)</i>	2,887	11.05	21.25	160.64	122.00	355.00
<i>Short<sup>US</sup> (Toxic)</i>						
<i>U.S. short interest (bps)</i>	935	0.00	0.23	3.12	2.14	7.90
<i>U.S. percent quoted spread (bps)</i>	935	10.39	27.91	52.56	68.71	65.13
<i>U.S. Amihud illiquidity</i>	930	0.09	0.65	9.03	4.89	24.12
<i>Idiosyncratic volatility (%)</i>	935	0.55	1.00	1.27	1.62	1.03
<i>U.S. lending fee (bps)</i>	795	11.37	18.00	142.49	116.01	323.58

**Table 4.2 (Cont'd)**

	N	25%	Median	Mean	75%	Std. Dev.
<i>Short<sup>US</sup> (Toxic<sup>down</sup>)</i>						
<i>U.S. short interest (bps)</i>	463	0.00	0.23	3.44	1.83	8.99
<i>U.S. percent quoted spread (bps)</i>	463	15.70	34.22	58.65	76.6	66.16
<i>U.S. Amihud illiquidity</i>	458	0.09	0.94	8.79	5.03	22.84
<i>Idiosyncratic volatility (%)</i>	463	0.69	1.11	1.36	1.74	1.04
<i>U.S. lending fee (bps)</i>	383	13.54	34.41	167.73	175.00	345.26
<i>Short<sup>US</sup> (Toxic<sup>up</sup>)</i>						
<i>U.S. short interest (bps)</i>	472	0.00	0.23	2.80	2.31	6.65
<i>U.S. percent quoted spread (bps)</i>	472	8.19	20.76	46.60	57.31	63.60
<i>U.S. Amihud illiquidity</i>	472	0.08	0.45	9.26	4.77	25.32
<i>Idiosyncratic volatility (%)</i>	472	0.48	0.88	1.18	1.50	1.01
<i>U.S. lending fee (bps)</i>	412	10.09	15.05	119.02	71.54	300.56
<i>Short<sup>US</sup> (Non-toxic)</i>						
<i>U.S. short interest (bps)</i>	2,454	0.00	0.26	2.92	2.03	7.41
<i>U.S. percent quoted spread (bps)</i>	2,454	9.89	27.15	52.21	67.62	65.15
<i>U.S. Amihud illiquidity</i>	2,449	0.07	0.52	10.10	5.24	26.76
<i>Idiosyncratic volatility (%)</i>	2,454	0.49	0.91	1.24	1.54	1.12
<i>U.S. lending fee (bps)</i>	2,092	11.00	22.30	167.54	125.78	366.07
<i>Short<sup>CA</sup> (Pooled)</i>						
<i>U.S. short interest (bps)</i>	3,216	0.00	0.38	3.47	2.55	8.38
<i>U.S. percent quoted spread (bps)</i>	3,216	9.64	25.00	46.29	58.24	60.02
<i>U.S. Amihud illiquidity</i>	3,209	0.07	0.50	9.98	4.52	27.50
<i>Idiosyncratic volatility (%)</i>	3,216	0.50	0.90	1.21	1.53	1.05
<i>U.S. lending fee (bps)</i>	2,826	11.95	18.14	137.25	106.14	313.81

**Table 4.3 : Correlations**

This table presents unconditional correlations between our main variables. Our sample includes 134 Canadian stocks that are cross-listed in the U.S. between July 2006 and December 2013.  $Short^{US}$  is a dummy that equals one if the U.S. price of the stock-pair is overvalued relative to the Canadian price in the arbitrage opportunity, and zero otherwise.  $Short^{CA}$  is a dummy that equals one if the Canadian price of the stock-pair is overvalued relative to the U.S. price in the arbitrage opportunity, and zero otherwise. Other variables are as defined in previous tables. P values are reported in parentheses.

	<i>U.S. short interest</i>	<i>U.S. percent quoted spread</i>	<i>U.S. Amihud illiquidity</i>	$ Ln(P^{US}/P^{CA}) $	$ Ln(R^{US}/R^{CA}) $	$Short^{US}$	$Short^{CA}$	<i>U.S. lending fee</i>	<i>Idiosyncratic volatility</i>	<i>Capitalization</i>
<i>U.S. short interest</i>	<b>1.00</b>									
<i>U.S. percent quoted spread</i>	<b>-0.10</b> (0.00)	<b>1.00</b>								
<i>U.S. Amihud illiquidity</i>	<b>-0.01</b> (0.00)	<b>0.66</b> (0.00)	<b>1.00</b>							
$ Ln(P^{US}/P^{CA}) $	<b>-0.05</b> (0.00)	<b>0.47</b> (0.00)	<b>0.10</b> (0.00)	<b>1.00</b>						
$ Ln(R^{US}/R^{CA}) $	<b>-0.06</b> (0.00)	<b>0.44</b> (0.00)	<b>0.14</b> (0.00)	<b>0.57</b> (0.00)	<b>1.00</b>					
$Short^{US}$	<b>-0.00</b> (0.08)	<b>0.06</b> (0.00)	<b>0.00</b> (0.07)	<b>0.29</b> (0.00)	<b>0.22</b> (0.00)	<b>1.00</b>				
$Short^{CA}$	<b>-0.00</b> (0.45)	<b>0.03</b> (0.00)	<b>0.01</b> (0.00)	<b>0.29</b> (0.00)	<b>0.20</b> (0.00)	<b>-0.02</b> (0.00)	<b>1.00</b>			
<i>U.S. lending fee</i>	<b>0.04</b> (0.00)	<b>0.28</b> (0.00)	<b>0.06</b> (0.00)	<b>0.14</b> (0.00)	<b>0.15</b> (0.00)	<b>0.01</b> (0.00)	<b>0.00</b> (0.63)	<b>1.00</b>		
<i>Idiosyncratic volatility</i>	<b>-0.10</b> (0.00)	<b>0.65</b> (0.00)	<b>0.09</b> (0.00)	<b>0.40</b> (0.00)	<b>0.43</b> (0.00)	<b>0.03</b> (0.00)	<b>0.03</b> (0.00)	<b>0.25</b> (0.00)	<b>1.00</b>	
<i>Capitalization</i>	<b>0.02</b> (0.00)	<b>-0.35</b> (0.00)	<b>-0.02</b> (0.00)	<b>-0.16</b> (0.00)	<b>-0.19</b> (0.00)	<b>-0.01</b> (0.01)	<b>-0.01</b> (0.00)	<b>-0.19</b> (0.00)	<b>-0.34</b> (0.00)	<b>1.00</b>

**Table 4.4 : The effect of short sales on liquidity and price parity deviation of cross-listed firms**

This table presents the effect of short sales on the liquidity and price parity deviation of cross-listed firms. Our sample includes 134 Canadian stocks that are cross-listed in the U.S. between July 2006 and December 2013. Panel A reports the results from estimating the following equation:

$$Liquidity_{i,t} = \alpha_{i,t} + \beta_1 Short\ interest_{i,t} + \beta_2 Controls_{i,t} + \mu_{i,t}.$$

Columns (1) and (2) use *percent quoted spread* as the liquidity measure. Columns (3) and (4) use *Amihud illiquidity* as the liquidity measure. *Ban* is a dummy variable that equals to one during the short selling ban period between 19 September 2008 and 8 October 2008, and zero otherwise. Other variables are as defined in previous tables.

Panel B reports the results from estimating the following equation:

$$Price\ parity\ deviation_{i,t} = \alpha_{i,t} + \beta_1 Short\ interest_{i,t} + \beta_2 Controls_{i,t} + \mu_{i,t}.$$

Columns (1) and (2) use  $|Ln(P^{US}/P^{CA})|$  as the price-parity deviation measure. Columns (3) and (4) use  $|Ln(R^{US}/R^{CA})|$  as the price-parity deviation measure. Variables are as defined in previous tables. All columns in this table include year dummy variables. Standard errors (reported in parentheses) are clustered by firm. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: The effect of short sales on the liquidity of cross-listed firms

Variable	(1) U.S. percent quoted spread	(2) U.S. percent quoted spread	(3) U.S. Amihud illiquidity	(4) U.S. Amihud illiquidity
<i>U.S. short interest</i>	<b>-16.06***</b> (4.20)	<b>-11.13***</b> (4.09)	<b>-4.29***</b> (1.41)	<b>-3.04*</b> (1.56)
<i>Capitalization</i>		<b>-12.68**</b> (5.41)		<b>-3.41</b> (2.09)
<i>Ban</i>		<b>9.20***</b> (2.75)		<b>0.96</b> (1.08)
<i>VIX</i>		<b>0.29***</b> (0.08)		<b>0.06*</b> (0.04)
<i>U.S. volatility</i>		<b>-0.53</b> (1.12)		<b>-0.55</b> (0.49)
<i>U.S. 1/price</i>		<b>103.98***</b> (19.63)		<b>24.51***</b> (8.97)
<i>U.S. dollar volume</i>		<b>0.07***</b> (0.02)		<b>0.03***</b> (0.01)
<i>Constant</i>	<b>44.29***</b> (2.95)	<b>109.76***</b> (41.55)	<b>7.42***</b> (1.16)	<b>25.99</b> (15.89)
<i>Firm fixed effects</i>	YES	YES	YES	YES
<i>Number of observations</i>	130,155	130,154	129,975	129,975
<i>R<sup>2</sup> (within)</i>	0.07	0.35	0.02	0.08

**Table 4.4 (Cont'd)**

Panel B: The effect of short sales on the price parity deviation of cross-listed firms

Variable	(1) $ \text{Ln}(P^{US}/P^{CA}) $	(2) $ \text{Ln}(P^{US}/P^{CA}) $	(3) $ \text{Ln}(R^{US}/R^{CA}) $	(4) $ \text{Ln}(R^{US}/R^{CA}) $
<i>U.S. short interest</i>	<b>-0.12***</b> (0.05)	<b>-0.10**</b> (0.04)	<b>-0.12**</b> (0.05)	<b>-0.10**</b> (0.04)
<i>Capitalization</i>		<b>-0.20***</b> (0.02)		<b>-0.20***</b> (0.03)
<i>Dividend yield</i>		<b>0.01*</b> (0.01)		<b>0.02**</b> (0.01)
<i>U.S. turnover</i>		<b>0.03***</b> (0.01)		<b>0.04***</b> (0.01)
<i>CA turnover</i>		<b>0.01**</b> (0.01)		<b>0.02***</b> (0.01)
<i>U.S. volatility</i>		<b>0.02</b> (0.02)		<b>0.03*</b> (0.02)
<i>CA volatility</i>		<b>-0.01</b> (0.01)		<b>-0.01</b> (0.01)
<i>VIX</i>		<b>0.01***</b> (0.00)		<b>0.01***</b> (0.00)
<i>CA index volatility</i>		<b>0.00</b> (0.00)		<b>-0.00</b> (0.00)
<i>FX volatility</i>		<b>0.02***</b> (0.01)		<b>0.04***</b> (0.01)
<i>Ban</i>		<b>0.14***</b> (0.05)		<b>0.22***</b> (0.05)
$ \text{Ln}(P^{US}/P^{CA}) $ (lag)		<b>0.13***</b> (0.02)		
$ \text{Ln}(R^{US}/R^{CA}) $ (lag)				<b>0.35***</b> (0.01)
<i>Constant</i>	<b>0.48***</b> (0.02)	<b>1.57***</b> (0.17)	<b>0.69***</b> (0.03)	<b>1.61***</b> (0.18)
<i>Firm fixed effects</i>	YES	YES	YES	YES
<i>Number of observations</i>	130,155	129,207	130,149	129,195
<i>R<sup>2</sup> (within)</i>	0.05	0.13	0.05	0.23

**Table 4.5 : The effect of short sales on liquidity: toxic versus non-toxic arbitrage opportunities**

This table presents the effect of short sales on the liquidity in cross-listing arbitrage opportunities. Our sample includes 134 Canadian stocks that are cross-listed in the U.S. for the  $\pm 5$  days around each Short\_US event between July 2006 and December 2013. This table reports the results from estimating the following three equations:

$$\begin{aligned}
 \text{Liquidity}_{i,t} &= \alpha_i + \beta_1 \text{Short interest}_{i,t} + \beta_2 \text{Short}_{i,t}^{US} + \beta_3 \text{Short interest}_{i,t} \times \text{Short}_{i,t}^{US} \\
 &\quad + \beta_4 \text{Controls}_{i,t} + \mu_{i,t} \\
 \text{Liquidity}_{i,t} &= \alpha_{i,t} + \text{Short interest}_{i,t} \times (\beta_1 + \beta_2 \text{Short}_{i,t}^{US} + \beta_3 \text{Toxic}_{i,t} + \beta_4 \text{Short}_{i,t}^{US} \times \text{Toxic}_{i,t}) \\
 &\quad + \beta_5 \text{Short}_{i,t}^{US} + \beta_6 \text{Toxic}_{i,t} + \beta_7 \text{Short}_{i,t}^{US} \times \text{Toxic}_{i,t} + \beta_8 \text{Controls}_{i,t} + \mu_{i,t} \\
 \text{Liquidity}_{i,t} &= \alpha_{i,t} + \text{Short interest}_{i,t} \\
 &\quad \times (\beta_1 + \beta_2 \text{Short}_{i,t}^{US} + \beta_3 \text{Toxic}_{i,t}^{up} + \beta_4 \text{Toxic}_{i,t}^{down} + \beta_5 \text{Short}_{i,t}^{US} \times \text{Toxic}_{i,t}^{up} \\
 &\quad + \beta_6 \text{Short}_{i,t}^{US} \times \text{Toxic}_{i,t}^{down}) + \beta_7 \text{Short}_{i,t}^{US} + \beta_8 \text{Toxic}_{i,t}^{up} + \beta_9 \text{Toxic}_{i,t}^{down} \\
 &\quad + \beta_{10} \text{Short}_{i,t}^{US} \times \text{Toxic}_{i,t}^{up} + \beta_{11} \text{Short}_{i,t}^{US} \times \text{Toxic}_{i,t}^{down} + \beta_{12} \text{Controls}_{i,t} + \mu_{i,t}
 \end{aligned}$$

Panel A uses *percent quoted spread* as the liquidity measure. Panel B uses *Amihud illiquidity* as the liquidity measure. Variables are as defined in previous tables. All columns in this table include year dummy variables. Standard errors (reported in parentheses) are clustered by firm. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Dependent variable is U.S. percent quoted spread

	(1)	(2)	(3)	(4)	(5)	(6)
<i>U.S. short interest</i>	<b>-12.16**</b> (4.89)	<b>-8.52**</b> (3.93)	<b>-11.50**</b> (4.83)	<b>-7.98**</b> (3.84)	<b>-11.49**</b> (4.83)	<b>-7.98**</b> (3.84)
<i>Short<sup>US</sup></i>	<b>6.19***</b> (1.04)	<b>4.70***</b> (0.86)	<b>6.27***</b> (1.18)	<b>4.57***</b> (1.01)	<b>6.27***</b> (1.18)	<b>4.57***</b> (1.01)
<i>Short<sup>US</sup> × U.S. short interest</i>	<b>-21.25***</b> (7.91)	<b>-16.79**</b> (7.69)	<b>-20.73**</b> (9.84)	<b>-16.29*</b> (9.71)	<b>-20.74**</b> (9.84)	<b>-16.30*</b> (9.71)
<i>Toxic</i>			<b>5.74***</b> (1.78)	<b>-0.53</b> (1.38)		
<i>Toxic × U.S. short interest</i>			<b>-55.98**</b> (22.10)	<b>-52.21***</b> (19.76)		
<i>Toxic × Short<sup>US</sup></i>			<b>-5.71*</b> (3.40)	<b>0.93</b> (2.57)		
<i>Toxic × Short<sup>US</sup> × U.S. short interest</i>			<b>52.12*</b> (28.36)	<b>48.63*</b> (25.32)		
<i>Toxic<sup>down</sup></i>					<b>5.17**</b> (2.20)	<b>-1.42</b> (2.13)
<i>Toxic<sup>down</sup> × U.S. short interest</i>					<b>-62.63**</b> (26.32)	<b>-58.44**</b> (23.50)
<i>Toxic<sup>down</sup> × Short<sup>US</sup></i>					<b>-5.90</b> (3.71)	<b>0.70</b> (2.81)
<i>Toxic<sup>down</sup> × Short<sup>US</sup> × U.S. short interest</i>					<b>66.78**</b> (31.47)	<b>61.01**</b> (28.79)
<i>Toxic<sup>up</sup></i>					<b>7.10</b> (4.84)	<b>1.58</b> (3.69)
<i>Toxic<sup>up</sup> × U.S. short interest</i>					<b>-34.18</b> (30.86)	<b>-30.67</b> (25.70)
<i>Toxic<sup>up</sup> × Short<sup>US</sup></i>					<b>-6.20</b> (5.68)	<b>-0.02</b> (4.70)
<i>Toxic<sup>up</sup> × Short<sup>US</sup> × U.S. short interest</i>					<b>16.06</b> (37.89)	<b>17.17</b> (33.28)

**Table 4.5 (Cont'd)**

<i>U.S. dollar volume</i>	<b>0.07**</b>		<b>0.07**</b>		<b>0.07**</b>	
	(0.03)		(0.03)		(0.03)	
<i>Ban</i>	<b>5.34*</b>		<b>5.39*</b>		<b>5.48*</b>	
	(3.18)		(3.21)		(3.24)	
<i>VIX</i>	<b>0.31***</b>		<b>0.31***</b>		<b>0.31***</b>	
	(0.10)		(0.10)		(0.10)	
<i>U.S. volatility</i>	<b>-3.46**</b>		<b>-3.45**</b>		<b>-3.44**</b>	
	(1.65)		(1.65)		(1.64)	
<i>Capitalization</i>	<b>-11.91*</b>		<b>-11.93*</b>		<b>-11.93*</b>	
	(6.19)		(6.18)		(6.18)	
<i>U.S. 1/price</i>	<b>106.28***</b>		<b>106.21***</b>		<b>106.21***</b>	
	(22.29)		(22.28)		(22.28)	
<i>Constant</i>	<b>50.28***</b>	<b>106.58**</b>	<b>50.23***</b>	<b>106.74**</b>	<b>50.22***</b>	<b>106.69**</b>
	(3.75)	(47.54)	(3.76)	(47.51)	(3.76)	(47.54)
<i>Firm fixed effects</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Number of observations</i>	27,768	27,768	27,768	27,768	27,768	27,768
<i>R<sup>2</sup> (within)</i>	0.09	0.37	0.09	0.37	0.09	0.37

Panel B: Dependent variable is U.S. Amihud illiquidity

	(1)	(2)	(3)	(4)	(5)	(6)
<i>U.S. short interest</i>	<b>-2.31</b>	<b>-1.36</b>	<b>-2.10</b>	<b>-1.17</b>	<b>-2.08</b>	<b>-1.16</b>
	(2.11)	(2.19)	(2.09)	(2.19)	(2.09)	(2.18)
<i>Short<sup>US</sup></i>	<b>1.32**</b>	<b>0.95**</b>	<b>1.75***</b>	<b>1.36**</b>	<b>1.75***</b>	<b>1.36**</b>
	(0.54)	(0.47)	(0.60)	(0.54)	(0.60)	(0.54)
<i>Short<sup>US</sup> × U.S. short interest</i>	<b>-5.44*</b>	<b>-4.47</b>	<b>-7.00*</b>	<b>-5.90</b>	<b>-7.00*</b>	<b>-5.90</b>
	(2.88)	(2.91)	(3.89)	(3.97)	(3.89)	(3.97)
<i>Toxic</i>			<b>2.17**</b>	<b>0.75</b>		
			(0.98)	(0.97)		
<i>Toxic × U.S. short interest</i>			<b>-16.95*</b>	<b>-15.80*</b>		
			(8.96)	(8.72)		
<i>Toxic × Short<sup>US</sup></i>			<b>-3.61**</b>	<b>-2.19</b>		
			(1.74)	(1.57)		
<i>Toxic × Short<sup>US</sup> × U.S. short interest</i>			<b>21.76*</b>	<b>20.24*</b>		
			(12.56)	(12.09)		
<i>Toxic<sup>down</sup></i>					<b>3.29***</b>	<b>1.85*</b>
					(1.12)	(1.02)
<i>Toxic<sup>down</sup> × U.S. short interest</i>					<b>-25.46**</b>	<b>-24.25**</b>
					(10.15)	(9.76)
<i>Toxic<sup>down</sup> × Short<sup>US</sup></i>					<b>-6.43***</b>	<b>-5.09**</b>
					(2.22)	(2.07)
<i>Toxic<sup>down</sup> × Short<sup>US</sup> × U.S. short interest</i>					<b>35.94**</b>	<b>34.20**</b>
					(14.11)	(13.81)
<i>Toxic<sup>up</sup></i>					<b>-0.52</b>	<b>-1.90</b>
					(2.47)	(2.30)
<i>Toxic<sup>up</sup> × U.S. short interest</i>					<b>4.97</b>	<b>6.02</b>
					(15.92)	(16.07)
<i>Toxic<sup>up</sup> × Short<sup>US</sup></i>					<b>0.77</b>	<b>2.23</b>
					(2.83)	(2.59)
<i>Toxic<sup>up</sup> × Short<sup>US</sup> × U.S. short interest</i>					<b>-8.14</b>	<b>-9.06</b>
					(18.24)	(18.12)
<i>U.S. dollar volume</i>		<b>0.03**</b>		<b>0.03**</b>		<b>0.03**</b>
		(0.01)		(0.01)		(0.01)
<i>Ban</i>		<b>1.03</b>		<b>1.06</b>		<b>1.11</b>
		(1.13)		(1.16)		(1.16)



**Table 4.5 (Cont'd)**

<i>VIX</i>		<b>0.07</b>		<b>0.07</b>		<b>0.07</b>
		(0.05)		(0.05)		(0.05)
<i>U.S. volatility</i>		<b>-1.74**</b>		<b>-1.75**</b>		<b>-1.76**</b>
		(0.69)		(0.69)		(0.69)
<i>Capitalization</i>		<b>-2.80</b>		<b>-2.80</b>		<b>-2.79</b>
		(2.52)		(2.52)		(2.52)
<i>U.S. 1/price</i>		<b>24.53**</b>		<b>24.53**</b>		<b>24.53**</b>
		(9.51)		(9.50)		(9.51)
<i>Constant</i>	<b>9.99***</b>	<b>23.79</b>	<b>9.99***</b>	<b>23.75</b>	<b>9.98***</b>	<b>23.72</b>
	(1.15)	(19.15)	(1.15)	(19.12)	(1.15)	(19.16)
<i>Firm fixed effects</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Number of observations</i>	27,739	27,739	27,739	27,739	27,739	27,739
<i>R<sup>2</sup> (within)</i>	0.02	0.08	0.02	0.08	0.02	0.08

**Table 4.6 : The effect of short sales on liquidity: arbitrage costs**

This table presents the effect of short sales on the liquidity in cross-listing arbitrage opportunities. Our sample includes 134 Canadian stocks that are cross-listed in the U.S. for the  $\pm 5$  days around each Short\_US event between July 2006 and December 2013. This table reports the results from estimating the following two equations:

$$\begin{aligned} Liquidity_{i,t} = & \alpha_{i,t} + Short\ interest_{i,t} \\ & \times (\beta_1 + \beta_2 Short_{i,t}^{US} + \beta_3 Toxic_{i,t} + \beta_4 High\ arbitrage\ cost_{i,t} + \beta_5 Short_{i,t}^{US} \times Toxic_{i,t} + \beta_6 Short_{i,t}^{US} \times High\ arbitrage\ cost_{i,t} + \beta_7 Toxic_{i,t} \\ & \times High\ arbitrage\ cost_{i,t} + \beta_8 Short_{i,t}^{US} \times Toxic_{i,t} \times High\ arbitrage\ cost_{i,t}) + \beta_9 Short_{i,t}^{US} + \beta_{10} Toxic_{i,t} + \beta_{11} High\ arbitrage\ cost_{i,t} \\ & + \beta_{12} Short_{i,t}^{US} \times Toxic_{i,t} + \beta_{13} Short_{i,t}^{US} \times High\ arbitrage\ cost_{i,t} + \beta_{14} Toxic_{i,t} \times High\ arbitrage\ cost_{i,t} + \beta_{15} Short_{i,t}^{US} \times Toxic_{i,t} \\ & \times High\ arbitrage\ cost_{i,t} + \beta_{16} Controls_{i,t} + \mu_{i,t} \end{aligned}$$

$$\begin{aligned} Liquidity_{i,t} = & \alpha_{i,t} + Short\ interest_{i,t} \\ & \times (\beta_1 + \beta_2 Short_{i,t}^{US} + \beta_3 Toxic_{i,t}^{up} + \beta_4 Toxic_{i,t}^{down} + \beta_5 High\ arbitrage\ cost_{i,t} + \beta_6 Short_{i,t}^{US} \times Toxic_{i,t}^{up} + \beta_7 Short_{i,t}^{US} \times Toxic_{i,t}^{down} \\ & + \beta_8 Short_{i,t}^{US} \times High\ arbitrage\ cost_{i,t} + \beta_9 Toxic_{i,t}^{up} \times High\ arbitrage\ cost_{i,t} + \beta_{10} Toxic_{i,t}^{down} \times High\ arbitrage\ cost_{i,t} + \beta_{11} Short_{i,t}^{US} \times Toxic_{i,t}^{up} \\ & \times High\ arbitrage\ cost_{i,t} + \beta_{12} Short_{i,t}^{US} \times Toxic_{i,t}^{down} \times High\ arbitrage\ cost_{i,t}) + \beta_{13} Short_{i,t}^{US} + \beta_{14} Toxic_{i,t}^{up} + \beta_{15} Toxic_{i,t}^{down} \\ & + \beta_{16} High\ arbitrage\ cost_{i,t} + \beta_{17} Short_{i,t}^{US} \times Toxic_{i,t}^{up} + \beta_{18} Short_{i,t}^{US} \times Toxic_{i,t}^{down} + \beta_{19} Short_{i,t}^{US} \times High\ arbitrage\ cost_{i,t} \\ & + \beta_{20} Toxic_{i,t}^{up} \times High\ arbitrage\ cost_{i,t} + \beta_{21} Toxic_{i,t}^{down} \times High\ arbitrage\ cost_{i,t} + \beta_{22} Short_{i,t}^{US} \times Toxic_{i,t}^{up} \times High\ arbitrage\ cost_{i,t} + \beta_{23} Short_{i,t}^{US} \\ & \times Toxic_{i,t}^{down} \times High\ arbitrage\ cost_{i,t} + \beta_{24} Controls_{i,t} + \mu_{i,t} \end{aligned}$$

Panel A uses U.S. lending fee as the arbitrage cost measure. Panel B uses idiosyncratic volatility as the arbitrage cost measure. *High lending fee* is a dummy that equals to one if the stock belongs to the top lending fee decile on day  $t$ , and zero otherwise. *High idiosyncratic volatility* is a dummy that equals to one if the stock belongs to the top idiosyncratic volatility decile on day  $t$ , and zero otherwise. Other variables are as defined in previous tables. Columns (1) to (4) in both Panel A and B use *percent quoted spread* as the liquidity measure. Columns (5) to (8) use *Amihud illiquidity* as the liquidity measure. All columns in this table include year dummy variables. Standard errors (reported in parentheses) are clustered by firm. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Arbitrage cost measure is U.S. lending fee

Variable	(1) U.S. percent quoted spread	(2) U.S. percent quoted spread	(3) U.S. percent quoted spread	(4) U.S. percent quoted spread	(5) U.S. Amihud illiquidity	(6) U.S. Amihud illiquidity	(7) U.S. Amihud illiquidity	(8) U.S. Amihud illiquidity
<i>U.S. short interest</i>	<b>-7.25*</b> (4.05)	<b>-6.28</b> (5.36)	<b>-7.24*</b> (4.05)	<b>-6.30</b> (5.35)	<b>-1.59</b> (1.57)	<b>-1.29</b> (2.27)	<b>-1.59</b> (1.57)	<b>-1.30</b> (2.26)
<i>Short<sup>US</sup></i>	<b>3.44***</b> (0.95)	<b>1.73**</b> (0.74)	<b>3.44***</b> (0.95)	<b>1.73**</b> (0.74)	<b>0.54</b> (0.41)	<b>0.15</b> (0.36)	<b>0.54</b> (0.41)	<b>0.15</b> (0.36)
<i>Short<sup>US</sup> × U.S. short interest</i>	<b>-7.77</b> (8.60)	<b>-5.66</b> (9.21)	<b>-7.78</b> (8.60)	<b>-5.68</b> (9.21)	<b>-2.85</b> (2.71)	<b>-2.43</b> (2.80)	<b>-2.87</b> (2.72)	<b>-2.46</b> (2.80)
<i>Toxic</i>	<b>3.61**</b> (1.67)	<b>-2.69*</b> (1.38)			<b>1.18</b> (1.18)	<b>-0.24</b> (1.16)		
<i>Toxic × U.S. short interest</i>	<b>-23.50*</b> (12.04)	<b>-19.42</b> (12.13)			<b>-5.28</b> (7.55)	<b>-3.94</b> (8.04)		
<i>Toxic × Short<sup>US</sup></i>	<b>-1.06</b> (2.90)	<b>5.88***</b> (2.19)			<b>-1.08</b> (1.78)	<b>0.39</b> (1.60)		
<i>Toxic × Short<sup>US</sup> × U.S. short interest</i>	<b>5.28</b> (18.48)	<b>1.42</b> (16.48)			<b>5.04</b> (9.83)	<b>3.45</b> (9.78)		
<i>High lending fee</i>	<b>8.12**</b> (3.54)	<b>4.98*</b> (2.53)	<b>8.11**</b> (3.54)	<b>4.96*</b> (2.54)	<b>1.93</b> (1.37)	<b>1.14</b> (1.25)	<b>1.90</b> (1.37)	<b>1.11</b> (1.24)
<i>High lending fee × U.S. short interest</i>	<b>-13.77</b> (12.23)	<b>-5.73</b> (10.13)	<b>-13.79</b> (12.24)	<b>-5.73</b> (10.12)	<b>-1.63</b> (5.09)	<b>0.33</b> (5.03)	<b>-1.61</b> (5.08)	<b>0.36</b> (5.03)
<i>High lending fee × Short<sup>US</sup></i>	<b>10.03***</b> (3.05)	<b>10.35***</b> (2.61)	<b>10.03***</b> (3.05)	<b>10.36***</b> (2.61)	<b>4.42***</b> (1.54)	<b>4.47***</b> (1.49)	<b>4.42***</b> (1.54)	<b>4.48***</b> (1.49)
<i>High lending fee × Short<sup>US</sup> × U.S. short interest</i>	<b>-35.59*</b> (19.85)	<b>-28.48</b> (18.48)	<b>-35.60*</b> (19.85)	<b>-28.49</b> (18.48)	<b>-10.83</b> (10.97)	<b>-8.75</b> (11.30)	<b>-10.83</b> (10.97)	<b>-8.73</b> (11.30)
<i>High lending fee × Toxic</i>	<b>7.36</b> (7.20)	<b>7.79</b> (5.57)			<b>3.77</b> (2.98)	<b>3.84</b> (2.87)		
<i>High lending fee × Toxic × U.S. short interest</i>	<b>-106.81***</b> (35.49)	<b>-110.87***</b> (30.95)			<b>-37.89**</b> (17.44)	<b>-39.44**</b> (16.85)		
<i>High lending fee × Toxic × Short<sup>US</sup></i>	<b>-15.71</b> (10.61)	<b>-17.53*</b> (8.87)			<b>-9.44*</b> (4.92)	<b>-9.79**</b> (4.67)		

**Table 4.6 (Cont'd)**

<i>High lending fee</i> $\times$ <i>Toxic</i> $\times$ <i>Short</i> <sup>US</sup> $\times$ <i>U.S. short interest</i>	<b>146.58***</b> (46.36)	<b>154.34***</b> (44.45)			<b>50.38*</b> (27.13)	<b>52.44**</b> (26.04)		
<i>Toxic</i> <sup>down</sup>			<b>3.25*</b> (1.66)	<b>-4.08**</b> (1.59)			<b>1.27</b> (1.05)	<b>-0.34</b> (1.02)
<i>Toxic</i> <sup>down</sup> $\times$ <i>U.S. short interest</i>			<b>-26.43**</b> (13.25)	<b>-18.69</b> (13.79)			<b>-7.19</b> (6.14)	<b>-5.07</b> (7.21)
<i>Toxic</i> <sup>down</sup> $\times$ <i>Short</i> <sup>US</sup>			<b>-1.74</b> (3.71)	<b>6.65**</b> (3.12)			<b>-2.08</b> (1.68)	<b>-0.33</b> (1.54)
<i>Toxic</i> <sup>down</sup> $\times$ <i>Short</i> <sup>US</sup> $\times$ <i>U.S. short interest</i>			<b>14.95</b> (20.50)	<b>-0.66</b> (21.94)			<b>10.19</b> (8.13)	<b>6.24</b> (9.06)
<i>High lending fee</i> $\times$ <i>Toxic</i> <sup>down</sup>			<b>6.77</b> (10.37)	<b>10.61</b> (8.13)			<b>9.23**</b> (4.02)	<b>10.05**</b> (3.90)
<i>High lending fee</i> $\times$ <i>Toxic</i> <sup>down</sup> $\times$ <i>U.S. short interest</i>			<b>-112.33***</b> (39.23)	<b>-127.49***</b> (27.54)			<b>-55.06***</b> (15.37)	<b>-59.10***</b> (13.95)
<i>High lending fee</i> $\times$ <i>Toxic</i> <sup>down</sup> $\times$ <i>Short</i> <sup>US</sup>			<b>-13.96</b> (12.57)	<b>-21.82**</b> (10.21)			<b>-17.48***</b> (6.60)	<b>-19.22***</b> (6.46)
<i>High lending fee</i> $\times$ <i>Toxic</i> <sup>down</sup> $\times$ <i>Short</i> <sup>US</sup> $\times$ <i>U.S. short interest</i>			<b>152.19***</b> (48.44)	<b>191.88***</b> (40.70)			<b>73.55***</b> (26.22)	<b>82.90***</b> (25.07)
<i>Toxic</i> <sup>up</sup>			<b>4.62</b> (4.13)	<b>1.05</b> (2.91)			<b>0.95</b> (3.07)	<b>-0.00</b> (2.84)
<i>Toxic</i> <sup>up</sup> $\times$ <i>U.S. short interest</i>			<b>-14.19</b> (26.89)	<b>-17.74</b> (23.58)			<b>-0.07</b> (20.42)	<b>-0.38</b> (20.32)
<i>Toxic</i> <sup>up</sup> $\times$ <i>Short</i> <sup>US</sup>			<b>-1.07</b> (4.45)	<b>2.65</b> (3.14)			<b>-0.02</b> (3.60)	<b>0.89</b> (3.29)
<i>Toxic</i> <sup>up</sup> $\times$ <i>Short</i> <sup>US</sup> $\times$ <i>U.S. short interest</i>			<b>-14.04</b> (29.90)	<b>3.12</b> (25.51)			<b>-4.36</b> (23.06)	<b>-1.65</b> (22.57)
<i>High lending fee</i> $\times$ <i>Toxic</i> <sup>up</sup>			<b>7.68</b> (14.37)	<b>1.37</b> (11.44)			<b>-5.32</b> (4.57)	<b>-6.67</b> (4.22)
<i>High lending fee</i> $\times$ <i>Toxic</i> <sup>up</sup> $\times$ <i>U.S. short interest</i>			<b>-84.57</b> (75.55)	<b>-61.37</b> (74.18)			<b>8.01</b> (25.71)	<b>12.68</b> (24.32)

**Table 4.6 (Cont'd)**

<i>High lending fee</i> $\times$ <i>Toxic</i> <sup>up</sup> $\times$ <i>Short</i> <sup>US</sup>			<b>-17.11</b>	<b>-8.87</b>			<b>3.18</b>	<b>5.06</b>
			(18.07)	(15.79)			(5.30)	(4.69)
<i>High lending fee</i> $\times$ <i>Toxic</i> <sup>up</sup> $\times$ <i>Short</i> <sup>US</sup> $\times$ <i>U.S. short interest</i>			<b>112.21</b>	<b>49.43</b>			<b>-4.09</b>	<b>-18.42</b>
			(87.11)	(89.31)			(30.58)	(31.03)
<i>U.S. dollar volume</i>	<b>0.06**</b>			<b>0.06**</b>		<b>0.03**</b>		<b>0.03**</b>
	(0.03)			(0.03)		(0.01)		(0.01)
<i>Ban</i>	<b>5.34*</b>			<b>5.48*</b>		<b>1.04</b>		<b>1.14</b>
	(3.14)			(3.14)		(1.13)		(1.14)
<i>VIX</i>	<b>0.32***</b>			<b>0.32***</b>		<b>0.07</b>		<b>0.07</b>
	(0.10)			(0.10)		(0.05)		(0.05)
<i>U.S. volatility</i>	<b>-3.29**</b>			<b>-3.28**</b>		<b>-1.70**</b>		<b>-1.70**</b>
	(1.58)			(1.57)		(0.66)		(0.66)
<i>Capitalization</i>	<b>-11.45*</b>			<b>-11.45*</b>		<b>-2.67</b>		<b>-2.66</b>
	(6.14)			(6.14)		(2.54)		(2.54)
<i>U.S. 1/price</i>	<b>106.75***</b>			<b>106.79***</b>		<b>24.67**</b>		<b>24.75**</b>
	(22.16)			(22.16)		(9.47)		(9.48)
<i>Constant</i>	<b>45.94***</b>	<b>100.50**</b>	<b>45.95***</b>	<b>100.47**</b>	<b>8.92***</b>	<b>22.16</b>	<b>8.91***</b>	<b>22.07</b>
	(3.80)	(47.16)	(3.81)	(47.17)	(1.07)	(19.40)	(1.07)	(19.42)
<i>Firm fixed effects</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Number of observations</i>	27,768	27,768	27,768	27,768	27,739	27,739	27,739	27,739
<i>R<sup>2</sup> (within)</i>	0.10	0.37	0.10	0.37	0.03	0.08	0.03	0.08

**Table 4.6 (Cont'd)**

Panel B: Arbitrage cost measure is idiosyncratic volatility

Variable	(1) U.S. percent quoted spread	(2) U.S. percent quoted spread	(3) U.S. percent quoted spread	(4) U.S. percent quoted spread	(5) U.S. Amihud illiquidity	(6) U.S. Amihud illiquidity	(7) U.S. Amihud illiquidity	(8) U.S. Amihud illiquidity
<i>U.S. short interest</i>	<b>-6.02</b> (5.00)	<b>-3.39</b> (4.14)	<b>-6.03</b> (5.00)	<b>-3.40</b> (4.14)	<b>0.94</b> (2.03)	<b>1.62</b> (2.20)	<b>0.97</b> (2.03)	<b>1.65</b> (2.20)
<i>Short<sup>US</sup></i>	<b>4.25***</b> (0.88)	<b>2.75***</b> (0.74)	<b>4.24***</b> (0.88)	<b>2.74***</b> (0.74)	<b>0.78</b> (0.47)	<b>0.43</b> (0.45)	<b>0.78</b> (0.47)	<b>0.43</b> (0.45)
<i>Short<sup>US</sup> × U.S. short interest</i>	<b>-10.65</b> (7.71)	<b>-8.78</b> (8.09)	<b>-10.66</b> (7.70)	<b>-8.82</b> (8.09)	<b>-1.94</b> (4.28)	<b>-1.41</b> (4.31)	<b>-1.94</b> (4.29)	<b>-1.43</b> (4.31)
<i>Toxic</i>	<b>4.44***</b> (1.59)	<b>-2.51*</b> (1.40)			<b>0.91</b> (0.80)	<b>-0.64</b> (0.81)		
<i>Toxic × U.S. short interest</i>	<b>-28.94**</b> (13.18)	<b>-27.06**</b> (12.42)			<b>-5.48</b> (5.72)	<b>-4.87</b> (6.16)		
<i>Toxic × Short<sup>US</sup></i>	<b>-4.17</b> (2.69)	<b>2.89</b> (2.12)			<b>-1.11</b> (1.29)	<b>0.42</b> (1.20)		
<i>Toxic × Short<sup>US</sup> × U.S. short interest</i>	<b>21.07</b> (17.63)	<b>21.18</b> (16.26)			<b>3.11</b> (8.54)	<b>2.39</b> (8.68)		
<i>High idiosyncratic volatility</i>	<b>20.66***</b> (4.56)	<b>8.36**</b> (3.95)	<b>20.65***</b> (4.55)	<b>8.35**</b> (3.95)	<b>6.62***</b> (1.91)	<b>3.82**</b> (1.62)	<b>6.62***</b> (1.91)	<b>3.81**</b> (1.62)
<i>High idiosyncratic volatility × U.S. short interest</i>	<b>-46.79***</b> (16.90)	<b>-43.80***</b> (15.14)	<b>-46.87***</b> (16.95)	<b>-43.86***</b> (15.18)	<b>-27.31***</b> (8.50)	<b>-26.46***</b> (8.07)	<b>-27.30***</b> (8.50)	<b>-26.43***</b> (8.07)
<i>High idiosyncratic volatility × Short<sup>US</sup></i>	<b>13.44***</b> (3.91)	<b>12.76***</b> (3.73)	<b>13.44***</b> (3.91)	<b>12.76***</b> (3.73)	<b>6.89**</b> (2.64)	<b>6.74**</b> (2.60)	<b>6.89**</b> (2.64)	<b>6.74**</b> (2.60)
<i>High idiosyncratic volatility × Short<sup>US</sup> × U.S. short interest</i>	<b>-135.97**</b> (57.21)	<b>-129.10**</b> (57.78)	<b>-136.15**</b> (57.30)	<b>-129.30**</b> (57.84)	<b>-99.24***</b> (29.02)	<b>-97.97***</b> (29.95)	<b>-99.08***</b> (29.02)	<b>-97.81***</b> (29.94)
<i>High idiosyncratic volatility × Toxic</i>	<b>5.34</b> (9.70)	<b>12.35</b> (8.59)			<b>8.19*</b> (4.32)	<b>9.72**</b> (4.34)		

**Table 4.6 (Cont'd)**

<i>High idiosyncratic volatility</i> $\times$ <i>Toxic</i> $\times$ <i>U.S. short interest</i>	<b>-99.11***</b> (25.98)	<b>-106.73***</b> (28.28)			<b>-35.01**</b> (14.14)	<b>-36.95**</b> (14.51)		
<i>High idiosyncratic volatility</i> $\times$ <i>Toxic</i> $\times$ <i>Short</i> <sup>US</sup>	<b>-5.89</b> (16.11)	<b>-11.46</b> (13.45)			<b>-16.85**</b> (6.84)	<b>-18.27***</b> (6.57)		
<i>High idiosyncratic volatility</i> $\times$ <i>Toxic</i> $\times$ <i>Short</i> <sup>US</sup> $\times$ <i>U.S. short interest</i>	<b>171.34*</b> (90.11)	<b>160.18**</b> (77.88)			<b>141.99***</b> (40.02)	<b>140.37***</b> (39.12)		
<i>Toxic</i> <sup>down</sup>			<b>4.71**</b> (1.90)	<b>-3.19*</b> (1.72)			<b>1.50</b> (0.92)	<b>-0.23</b> (0.88)
<i>Toxic</i> <sup>down</sup> $\times$ <i>U.S. short interest</i>			<b>-34.32**</b> (16.07)	<b>-31.84**</b> (14.57)			<b>-9.27</b> (6.15)	<b>-8.59</b> (6.59)
<i>Toxic</i> <sup>down</sup> $\times$ <i>Short</i> <sup>US</sup>			<b>-6.19*</b> (3.16)	<b>1.15</b> (2.44)			<b>-2.77*</b> (1.50)	<b>-1.22</b> (1.40)
<i>Toxic</i> <sup>down</sup> $\times$ <i>Short</i> <sup>US</sup> $\times$ <i>U.S. short interest</i>			<b>36.94*</b> (19.65)	<b>35.77*</b> (19.39)			<b>10.08</b> (8.80)	<b>9.35</b> (9.15)
<i>High idiosyncratic volatility</i> $\times$ <i>Toxic</i> <sup>down</sup>			<b>-0.63</b> (11.94)	<b>12.64</b> (11.49)			<b>15.43**</b> (6.86)	<b>18.34***</b> (6.84)
<i>High idiosyncratic volatility</i> $\times$ <i>Toxic</i> <sup>down</sup> $\times$ <i>U.S. short interest</i>			<b>-77.03**</b> (31.17)	<b>-88.86***</b> (31.34)			<b>-48.18***</b> (15.99)	<b>-50.94***</b> (15.66)
<i>High idiosyncratic volatility</i> $\times$ <i>Toxic</i> <sup>down</sup> $\times$ <i>Short</i> <sup>US</sup>			<b>4.53</b> (13.94)	<b>-5.73</b> (12.39)			<b>-27.85***</b> (10.64)	<b>-30.43***</b> (10.57)
<i>High idiosyncratic volatility</i> $\times$ <i>Toxic</i> <sup>down</sup> $\times$ <i>Short</i> <sup>US</sup> $\times$ <i>U.S. short interest</i>			<b>137.40*</b> (77.88)	<b>126.60*</b> (73.53)			<b>182.88***</b> (48.07)	<b>180.93***</b> (46.68)
<i>Toxic</i> <sup>up</sup>			<b>3.77</b> (3.49)	<b>-0.72</b> (2.45)			<b>-0.58</b> (1.87)	<b>-1.72</b> (1.71)
<i>Toxic</i> <sup>up</sup> $\times$ <i>U.S. short interest</i>			<b>-16.57</b> (21.78)	<b>-15.11</b> (20.05)			<b>2.91</b> (13.72)	<b>3.57</b> (14.18)
<i>Toxic</i> <sup>up</sup> $\times$ <i>Short</i> <sup>US</sup>			<b>-1.76</b> (3.89)	<b>3.41</b> (2.87)			<b>1.39</b> (2.23)	<b>2.63</b> (2.03)
<i>Toxic</i> <sup>up</sup> $\times$ <i>Short</i> <sup>US</sup> $\times$ <i>U.S. short interest</i>			<b>-8.08</b> (25.49)	<b>-4.85</b> (23.19)			<b>-9.33</b> (15.80)	<b>-9.87</b> (16.21)

**Table 4.6 (Cont'd)**

<i>High idiosyncratic volatility</i> × <i>Toxic</i> <sup>up</sup>			<b>15.83</b>	<b>15.55</b>			<b>-1.75</b>	<b>-1.71</b>
			(19.94)	(17.81)			(4.92)	(5.28)
<i>High idiosyncratic volatility</i> × <i>Toxic</i> <sup>up</sup> × <i>U.S. short interest</i>			<b>-491.30</b>	<b>-856.86**</b>			<b>133.77</b>	<b>47.24</b>
			(488.66)	(431.16)			(168.63)	(177.30)
<i>High idiosyncratic volatility</i> × <i>Toxic</i> <sup>up</sup> × <i>Short</i> <sup>US</sup>			<b>-21.69</b>	<b>-21.85</b>			<b>-1.21</b>	<b>-1.38</b>
			(27.11)	(24.16)			(6.68)	(6.40)
<i>High idiosyncratic volatility</i> × <i>Toxic</i> <sup>up</sup> × <i>Short</i> <sup>US</sup> × <i>U.S. short interest</i>			<b>567.75</b>	<b>926.69*</b>			<b>-129.59</b>	<b>-42.18</b>
			(562.81)	(509.22)			(181.79)	(185.65)
<i>U.S. dollar volume</i>		<b>0.07**</b>		<b>0.07**</b>		<b>0.03**</b>		<b>0.03**</b>
		(0.03)		(0.03)		(0.01)		(0.01)
<i>Ban</i>		<b>5.39*</b>		<b>5.51*</b>		<b>1.03</b>		<b>1.09</b>
		(3.16)		(3.15)		(1.12)		(1.13)
<i>VIX</i>		<b>0.33***</b>		<b>0.33***</b>		<b>0.08*</b>		<b>0.08*</b>
		(0.10)		(0.10)		(0.05)		(0.05)
<i>U.S. volatility</i>		<b>-3.50**</b>		<b>-3.50**</b>		<b>-1.77**</b>		<b>-1.77**</b>
		(1.62)		(1.62)		(0.68)		(0.68)
<i>Capitalization</i>		<b>-12.06*</b>		<b>-12.06*</b>		<b>-2.85</b>		<b>-2.83</b>
		(6.14)		(6.14)		(2.51)		(2.52)
<i>U.S. 1/price</i>		<b>100.75***</b>		<b>100.78***</b>		<b>22.21**</b>		<b>22.28**</b>
		(22.41)		(22.41)		(9.11)		(9.13)
<i>Constant</i>	<b>45.92***</b>	<b>106.80**</b>	<b>45.92***</b>	<b>106.73**</b>	<b>8.65***</b>	<b>23.72</b>	<b>8.64***</b>	<b>23.59</b>
	(3.63)	(47.08)	(3.63)	(47.11)	(0.97)	(19.11)	(0.98)	(19.17)
<i>Firm fixed effects</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Number of observations</i>	27,768	27,768	27,768	27,768	27,739	27,739	27,739	27,739
<i>R<sup>2</sup> (within)</i>	0.10	0.37	0.10	0.37	0.03	0.08	0.03	0.08



**Table 4.7 : Matching portfolios**

This table presents the effect of short sales on the liquidity in cross-listing arbitrage opportunities based on abnormal measurements. Our sample includes 134 Canadian stocks that are cross-listed in the U.S. for the  $\pm 5$  days around each  $Short^{US}$  event between July 2006 and December 2013. *Abnormal short interest* is the short interest of the treatment firm minus the average short interest of the associated size and price matched portfolio. *Abnormal percent quoted spread* is the percent quoted spread of the treatment firm minus the average percent quoted spread of the associated size and price matched portfolio. *Abnormal Amihud illiquidity* is the Amihud illiquidity of the treatment firm minus the average Amihud illiquidity of the associated size and price matched portfolio. *High abnormal lending fee* is a dummy that equals to one if the difference between the lending fee of the treatment firm and that of the associated size and price matched portfolio belongs to the top abnormal lending fee decile on day  $t$ , and zero otherwise. The estimation equations are similar to that in Table 4, 5 and 6. Panel A uses *abnormal percent quoted spread* as the liquidity measure. Panel B uses *abnormal Amihud illiquidity* as the liquidity measure. Variables are as defined in previous tables. Standard errors (reported in parentheses) are clustered by firm. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Dependent variable is U.S. abnormal percent quoted spread

	(1)	(2)	(3)	(4)	(5)	(6)
<i>U.S. abnormal short interest</i>	<b>-82.70***</b> (14.10)	<b>-80.45***</b> (13.99)	<b>-79.51***</b> (13.92)	<b>-79.53***</b> (13.91)	<b>-75.60***</b> (15.42)	<b>-75.63***</b> (15.40)
<i>Short<sup>US</sup></i>		<b>-6.17***</b> (1.67)	<b>-5.64***</b> (1.76)	<b>-5.63***</b> (1.76)	<b>-7.76***</b> (2.12)	<b>-7.76***</b> (2.12)
<i>Short<sup>US</sup> × U.S. abnormal short interest</i>		<b>-19.81***</b> (6.44)	<b>-19.74***</b> (7.41)	<b>-19.74***</b> (7.41)	<b>-22.29**</b> (9.37)	<b>-22.28**</b> (9.38)
<i>Toxic</i>			<b>-8.16*</b> (4.74)		<b>2.97</b> (4.07)	
<i>Toxic × U.S. abnormal short interest</i>			<b>-51.57**</b> (20.02)		<b>-14.35</b> (17.29)	
<i>Toxic × Short<sup>US</sup></i>			<b>5.76</b> (6.82)		<b>-1.06</b> (6.72)	
<i>Toxic × Short<sup>US</sup> × U.S. abnormal short interest</i>			<b>47.84*</b> (25.39)		<b>22.19</b> (26.66)	
<i>High abnormal lending fee</i>					<b>2.60</b> (5.26)	<b>2.60</b> (5.26)
<i>High abnormal lending fee × U.S. abnormal short interest</i>					<b>-19.08</b> (21.68)	<b>-19.10</b> (21.66)

**Table 4.7 (Cont'd)**

<i>High abnormal lending fee</i> $\times$ <i>Short</i> <sup>US</sup>		<b>6.31</b> (4.86)	<b>6.32</b> (4.86)
<i>High abnormal lending fee</i> $\times$ <i>Short</i> <sup>US</sup> $\times$ <i>U.S. abnormal short interest</i>		<b>-5.20</b> (24.66)	<b>-5.09</b> (24.68)
<i>High abnormal lending fee</i> $\times$ <i>Toxic</i>		<b>-44.67***</b> (11.95)	
<i>High abnormal lending fee</i> $\times$ <i>Toxic</i> $\times$ <i>U.S. abnormal short interest</i>		<b>-174.56***</b> (43.19)	
<i>High abnormal lending fee</i> $\times$ <i>Toxic</i> $\times$ <i>Short</i> <sup>US</sup>		<b>31.30*</b> (16.34)	
<i>High abnormal lending fee</i> $\times$ <i>Toxic</i> $\times$ <i>Short</i> <sup>US</sup> $\times$ <i>U.S. abnormal short interest</i>		<b>150.77**</b> (58.86)	
<i>Toxic</i> <sup>down</sup>	<b>-11.64**</b> (5.39)		<b>3.24</b> (4.36)
<i>Toxic</i> <sup>down</sup> $\times$ <i>U.S. abnormal short interest</i>	<b>-71.40***</b> (21.62)		<b>-29.28</b> (17.80)
<i>Toxic</i> <sup>down</sup> $\times$ <i>Short</i> <sup>US</sup>	<b>9.02</b> (8.32)		<b>4.00</b> (8.20)
<i>Toxic</i> <sup>down</sup> $\times$ <i>Short</i> <sup>US</sup> $\times$ <i>U.S. abnormal short interest</i>	<b>63.91**</b> (31.96)		<b>47.67</b> (35.12)
<i>High abnormal lending fee</i> $\times$ <i>Toxic</i> <sup>down</sup>			<b>-57.90***</b> (16.36)
<i>High abnormal lending fee</i> $\times$ <i>Toxic</i> <sup>down</sup> $\times$ <i>U.S. abnormal short interest</i>			<b>-156.90***</b> (58.79)
<i>High abnormal lending fee</i> $\times$ <i>Toxic</i> <sup>down</sup> $\times$ <i>Short</i> <sup>US</sup>			<b>27.09</b> (24.54)
<i>High abnormal lending fee</i> $\times$ <i>Toxic</i> <sup>down</sup> $\times$ <i>Short</i> <sup>US</sup> $\times$ <i>U.S. abnormal short interest</i>			<b>92.30</b> (86.24)
<i>Toxic</i> <sup>up</sup>	<b>1.25</b> (10.85)		<b>4.48</b> (10.11)
<i>Toxic</i> <sup>up</sup> $\times$ <i>U.S. abnormal short interest</i>	<b>12.99</b> (71.61)		<b>53.07</b> (79.42)

**Table 4.7 (Cont'd)**

$Toxic^{up} \times Short^{US}$				<b>-3.31</b>	<b>-8.24</b>
				(11.45)	(11.14)
$Toxic^{up} \times Short^{US} \times U.S. \text{ abnormal short interest}$				<b>-12.27</b>	<b>-59.83</b>
				(73.33)	(79.39)
$High \text{ abnormal lending fee} \times Toxic^{up}$					<b>-17.87</b>
					(25.34)
$High \text{ abnormal lending fee} \times Toxic^{up} \times U.S. \text{ abnormal short interest}$					<b>-201.92</b>
					(141.88)
$High \text{ abnormal lending fee} \times Toxic^{up} \times Short^{US}$					<b>25.26</b>
					(27.85)
$High \text{ abnormal lending fee} \times Toxic^{up} \times Short^{US} \times U.S. \text{ abnormal short interest}$					<b>229.54</b>
					(148.70)
$U.S. \text{ dollar volume}$	<b>-0.03</b>	<b>-0.03</b>	<b>-0.03</b>	<b>-0.03</b>	<b>-0.03</b>
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
$Ban$	<b>-23.73***</b>	<b>-23.72***</b>	<b>-23.89***</b>	<b>-24.00***</b>	<b>-23.74***</b>
	(6.70)	(6.69)	(6.70)	(6.77)	(6.73)
$VIX$	<b>-0.43***</b>	<b>-0.42***</b>	<b>-0.42***</b>	<b>-0.42***</b>	<b>-0.42***</b>
	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)
$U.S. \text{ volatility}$	<b>1.27</b>	<b>1.27</b>	<b>1.21</b>	<b>1.20</b>	<b>1.30</b>
	(2.01)	(2.01)	(2.01)	(2.01)	(2.01)
$Capitalization$	<b>13.86*</b>	<b>13.81*</b>	<b>13.82*</b>	<b>13.82*</b>	<b>14.45*</b>
	(7.60)	(7.59)	(7.59)	(7.59)	(7.56)
$U.S. 1/price$	<b>-129.68***</b>	<b>-129.60***</b>	<b>-129.63***</b>	<b>-129.65***</b>	<b>-127.70***</b>
	(30.10)	(30.09)	(30.09)	(30.08)	(30.25)
$Constant$	<b>-108.22*</b>	<b>-107.26*</b>	<b>-107.14*</b>	<b>-107.15*</b>	<b>-112.69*</b>
	(58.67)	(58.58)	(58.56)	(58.54)	(58.50)
$Firm \text{ fixed effects}$	Yes	Yes	Yes	Yes	Yes
$Number \text{ of observations}$	27,740	27,740	27,740	27,740	27,740
$R^2 \text{ (within)}$	0.19	0.19	0.19	0.19	0.19

Panel B: Dependent variable is U.S. abnormal Amihud illiquidity

	(1)	(2)	(3)	(4)	(5)	(6)
<i>U.S. abnormal short interest</i>	<b>-134.44***</b> (28.54)	<b>-127.27***</b> (28.03)	<b>-124.21***</b> (27.93)	<b>-124.21***</b> (27.94)	<b>-103.06***</b> (27.22)	<b>-103.12***</b> (27.25)
<i>Short<sup>US</sup></i>		<b>-11.96***</b> (4.55)	<b>-11.38**</b> (4.91)	<b>-11.38**</b> (4.91)	<b>-7.23</b> (4.73)	<b>-7.24</b> (4.73)
<i>Short<sup>US</sup> × U.S. abnormal short interest</i>		<b>-61.41***</b> (17.86)	<b>-60.62***</b> (21.53)	<b>-60.63***</b> (21.53)	<b>-51.18**</b> (20.70)	<b>-51.15**</b> (20.71)
<i>Toxic</i>			<b>-25.23*</b> (14.69)		<b>14.71</b> (14.03)	
<i>Toxic × U.S. abnormal short interest</i>			<b>-168.24***</b> (56.73)		<b>-35.51</b> (45.08)	
<i>Toxic × Short<sup>US</sup></i>			<b>21.79</b> (18.58)		<b>-18.09</b> (16.14)	
<i>Toxic × Short<sup>US</sup> × U.S. abnormal short interest</i>			<b>154.76**</b> (66.16)		<b>37.29</b> (54.13)	
<i>High abnormal lending fee</i>					<b>-8.72</b> (11.82)	<b>-8.80</b> (11.80)
<i>High abnormal lending fee × U.S. abnormal short interest</i>					<b>-92.47*</b> (51.35)	<b>-92.57*</b> (51.34)
<i>High abnormal lending fee × Short<sup>US</sup></i>					<b>-10.25</b> (13.06)	<b>-10.23</b> (13.07)
<i>High abnormal lending fee × Short<sup>US</sup> × U.S. abnormal short interest</i>					<b>-23.33</b> (53.70)	<b>-23.22</b> (53.72)
<i>High abnormal lending fee × Toxic</i>					<b>-132.54***</b> (39.69)	
<i>High abnormal lending fee × Toxic × U.S. abnormal short interest</i>					<b>-474.28***</b> (119.38)	
<i>High abnormal lending fee × Toxic × Short<sup>US</sup></i>					<b>130.42**</b> (51.40)	
<i>High abnormal lending fee × Toxic × Short<sup>US</sup> × U.S. abnormal short interest</i>					<b>417.83***</b> (156.59)	

**Table 4.7 (Cont'd)**

$Toxic^{down}$	<b>-27.58</b> (18.51)	<b>25.65</b> (18.84)
$Toxic^{down} \times U.S. \text{ abnormal short interest}$	<b>-173.05**</b> (67.52)	<b>-17.13</b> (57.08)
$Toxic^{down} \times Short^{US}$	<b>14.49</b> (24.56)	<b>-23.30</b> (18.58)
$Toxic^{down} \times Short^{US} \times U.S. \text{ abnormal short interest}$	<b>132.46*</b> (76.33)	<b>29.74</b> (57.20)
$High \text{ abnormal lending fee} \times Toxic^{down}$		<b>-169.19***</b> (41.72)
$High \text{ abnormal lending fee} \times Toxic^{down} \times U.S. \text{ abnormal short interest}$		<b>-426.42**</b> (168.37)
$High \text{ abnormal lending fee} \times Toxic^{down} \times Short^{US}$		<b>116.31*</b> (65.55)
$High \text{ abnormal lending fee} \times Toxic^{down} \times Short^{US} \times U.S. \text{ abnormal short interest}$		<b>275.15</b> (202.03)
$Toxic^{up}$	<b>-20.04</b> (25.12)	<b>-8.46</b> (20.92)
$Toxic^{up} \times U.S. \text{ abnormal short interest}$	<b>-157.99</b> (96.77)	<b>-52.54</b> (81.95)
$Toxic^{up} \times Short^{US}$	<b>27.46</b> (27.63)	<b>-0.82</b> (25.19)
$Toxic^{up} \times Short^{US} \times U.S. \text{ abnormal short interest}$	<b>180.10</b> (108.86)	<b>39.87</b> (95.91)
$High \text{ abnormal lending fee} \times Toxic^{up}$		<b>-49.66</b> (86.01)
$High \text{ abnormal lending fee} \times Toxic^{up} \times U.S. \text{ abnormal short interest}$		<b>-477.25</b> (351.29)
$High \text{ abnormal lending fee} \times Toxic^{up} \times Short^{US}$		<b>108.61</b> (86.77)
$High \text{ abnormal lending fee} \times Toxic^{up} \times Short^{US} \times U.S. \text{ abnormal short interest}$		<b>540.16</b> (360.45)

**Table 4.7 (Cont'd)**

<i>U.S. dollar volume</i>	<b>-0.13</b> (0.09)	<b>-0.13</b> (0.09)	<b>-0.12</b> (0.09)	<b>-0.12</b> (0.09)	<b>-0.13</b> (0.09)	<b>-0.13</b> (0.09)
<i>Ban</i>	<b>-55.95***</b> (19.18)	<b>-55.85***</b> (19.15)	<b>-56.62***</b> (19.19)	<b>-56.35***</b> (19.30)	<b>-49.03***</b> (18.60)	<b>-49.41***</b> (18.65)
<i>VIX</i>	<b>-1.41***</b> (0.48)	<b>-1.41***</b> (0.48)	<b>-1.41***</b> (0.48)	<b>-1.41***</b> (0.48)	<b>-1.21***</b> (0.45)	<b>-1.20***</b> (0.45)
<i>U.S. volatility</i>	<b>5.35</b> (5.25)	<b>5.31</b> (5.25)	<b>5.16</b> (5.24)	<b>5.17</b> (5.24)	<b>3.16</b> (4.82)	<b>3.12</b> (4.82)
<i>Capitalization</i>	<b>3.17</b> (16.94)	<b>3.15</b> (16.93)	<b>3.20</b> (16.93)	<b>3.23</b> (16.92)	<b>4.65</b> (16.95)	<b>4.78</b> (16.92)
<i>U.S. 1/price</i>	<b>-686.28***</b> (97.66)	<b>-686.03***</b> (97.65)	<b>-686.06***</b> (97.67)	<b>-685.93***</b> (97.68)	<b>-663.06***</b> (98.22)	<b>-662.58***</b> (98.16)
<i>Constant</i>	<b>45.73</b> (135.79)	<b>47.19</b> (135.69)	<b>47.39</b> (135.68)	<b>47.11</b> (135.60)	<b>33.31</b> (136.78)	<b>32.25</b> (136.45)
<i>Control</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Firm fixed effects</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Number of observations</i>	27,711	27,711	27,711	27,711	27,198	27,198
<i>R<sup>2</sup> (within)</i>	0.27	0.27	0.27	0.27	0.26	0.26

**Table 4.8: Robustness tests –instrumental variables**

This table presents the effect of short sales on the liquidity in cross-listing arbitrage opportunities based on 2SLS instrumental variable estimation. Our sample includes 134 Canadian stocks that are cross-listed in the U.S. for the  $\pm 5$  days around each  $Short^{US}$  event between July 2006 and December 2013. Panel A uses *percent quoted spread* as the liquidity measure. Panel B uses *Amihud illiquidity* as the liquidity measure. The instrumental variables include lagged U.S. short interest, lagged one day change in U.S. lending fee, and their interaction terms with the set of key dummy variables (e.g.,  $Short^{US}$ ,  $Toxic$ ,  $Toxic^{up}$ ,  $Toxic^{down}$ , and  $High\ abnormal\ lending\ fee$ ). Explanatory variables with hat are predicted by our set of instrumental variables in the first-stage regressions. Variables are as defined in previous tables. Anderson-Rubin Wald F statistic and Anderson-Rubin Wald Chi-sq statistic are results of the weak instrument robust inference. Hansen's J-test value is the result of over-identification test. Standard errors (reported in parentheses) are clustered by firm. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Dependent variable is U.S. percent quoted spread

	(1)	(2)	(3)	(4)	(5)
$U.S. \widehat{Short\ interest}$	<b>-95.66***</b> (19.85)	<b>-94.03***</b> (19.60)	<b>-94.01***</b> (19.60)	<b>-110.03***</b> (19.27)	<b>-110.01***</b> (19.27)
$Short^{US}$	<b>5.70***</b> (1.44)	<b>5.54***</b> (1.48)	<b>5.53***</b> (1.48)	<b>3.55***</b> (1.22)	<b>3.55***</b> (1.22)
$Short^{US} \times U.S. \widehat{Short\ interest}$	<b>-56.55**</b> (25.15)	<b>-72.89**</b> (30.07)	<b>-72.88**</b> (30.07)	<b>-50.88*</b> (29.17)	<b>-50.95*</b> (29.20)
$Toxic$		<b>3.27</b> (3.41)		<b>0.93</b> (2.53)	
$Toxic \times U.S. \widehat{Short\ interest}$		<b>-158.67*</b> (88.21)		<b>-98.01</b> (65.76)	
$Toxic \times Short^{US}$		<b>-2.39</b> (4.35)		<b>1.94</b> (3.82)	
$Toxic \times Short^{US} \times U.S. \widehat{Short\ interest}$		<b>205.93*</b> (108.12)		<b>115.77</b> (89.53)	
$High\ lending\ fee$				<b>5.61</b> (6.34)	<b>5.60</b> (6.33)
$High\ lending\ fee \times U.S. \widehat{Short\ interest}$				<b>38.12</b> (37.93)	<b>38.11</b> (37.93)
$High\ lending\ fee \times Short^{US}$				<b>12.21***</b> (4.41)	<b>12.20***</b> (4.40)

**Table 4.8 (Cont'd)**

$High\ lending\ fee \times \widehat{Short}^{US} \times U.S.Short\ interest$		<b>-98.95</b> (62.62)	<b>-98.80</b> (62.59)
$High\ lending\ fee \times Toxic$		<b>-34.45</b> (23.28)	
$High\ lending\ fee \times \widehat{Toxic} \times U.S.Short\ interest$		<b>-790.34</b> (640.59)	
$High\ lending\ fee \times Toxic \times Short^{US}$		<b>23.62</b> (24.20)	
$High\ lending\ fee \times Toxic \times \widehat{Short}^{US} \times U.S.Short\ interest$		<b>915.29</b> (634.95)	
$Toxic^{down}$	<b>4.46</b> (4.44)		<b>1.18</b> (3.07)
$Toxic^{down} \times \widehat{U.S.Short\ interest}$	<b>-201.76**</b> (100.20)		<b>-140.63*</b> (73.34)
$Toxic^{down} \times Short^{US}$	<b>-6.36</b> (6.37)		<b>1.28</b> (5.08)
$Toxic^{down} \times \widehat{Short}^{US} \times U.S.Short\ interest$	<b>284.00**</b> (124.18)		<b>160.24*</b> (95.19)
$High\ lending\ fee \times Toxic^{down}$			<b>-33.78*</b> (19.33)
$High\ lending\ fee \times \widehat{Toxic^{down}} \times U.S.Short\ interest$			<b>-817.80</b> (642.38)
$High\ lending\ fee \times Toxic^{down} \times Short^{US}$			<b>9.96</b> (20.46)
$High\ lending\ fee \times \widehat{Toxic^{down}} \times \widehat{Short}^{US} \times U.S.Short\ interest$			<b>1025.35*</b> (626.71)
$Toxic^{up}$	<b>1.83</b> (4.55)		<b>1.67</b> (4.16)
$Toxic^{up} \times \widehat{U.S.Short\ interest}$	<b>-87.09</b> (98.33)		<b>-15.43</b> (57.29)
$Toxic^{up} \times Short^{US}$	<b>1.71</b> (4.91)		<b>1.59</b> (4.45)



**Table 4.8 (Cont'd)**

$Toxic^{up} \times Short^{US} \times U.S.Short\ interest$			<b>88.09</b> (116.31)		<b>30.08</b> (83.06)
$High\ lending\ fee \times Toxic^{up}$					<b>-25.50*</b> (15.48)
$High\ lending\ fee \times Toxic^{up} \times U.S.Short\ interest$					<b>381.10</b> (334.70)
$High\ lending\ fee \times Toxic^{up} \times Short^{US}$					<b>27.69</b> (20.61)
$High\ lending\ fee \times Toxic^{up} \times Short^{US} \times U.S.Short\ interest$					<b>-373.71</b> (377.56)
<i>U.S. dollar volume</i>	<b>0.05</b> (0.03)	<b>0.05</b> (0.03)	<b>0.05</b> (0.03)	<b>0.05</b> (0.03)	<b>0.05</b> (0.03)
<i>Ban</i>	<b>1.26</b> (2.61)	<b>1.20</b> (2.65)	<b>1.27</b> (2.66)	<b>1.74</b> (2.59)	<b>1.74</b> (2.61)
<i>VIX</i>	<b>0.34***</b> (0.11)	<b>0.34***</b> (0.11)	<b>0.34***</b> (0.11)	<b>0.35***</b> (0.11)	<b>0.35***</b> (0.11)
<i>U.S. volatility</i>	<b>0.26</b> (1.54)	<b>0.31</b> (1.54)	<b>0.31</b> (1.54)	<b>0.20</b> (1.50)	<b>0.19</b> (1.50)
<i>Capitalization</i>	<b>-12.79***</b> (2.23)	<b>-12.81***</b> (2.24)	<b>-12.81***</b> (2.24)	<b>-12.45***</b> (2.03)	<b>-12.45***</b> (2.03)
<i>U.S. 1/price</i>	<b>63.93***</b> (13.19)	<b>63.90***</b> (13.22)	<b>63.96***</b> (13.21)	<b>61.83***</b> (13.60)	<b>61.90***</b> (13.57)
<i>Constant</i>	<b>111.03***</b> (17.92)	<b>111.03***</b> (17.98)	<b>111.01***</b> (17.98)	<b>107.13***</b> (16.32)	<b>107.07***</b> (16.27)
<i>Firm fixed effects</i>	Yes	Yes	Yes	Yes	Yes
<i>Number of observations</i>	23,460	23,460	23,460	23,460	23,460
<i>R<sup>2</sup> (within)</i>	0.53	0.53	0.53	0.53	0.53
<i>Anderson-Rubin Wald F statistic</i>	<b>6.34***</b>	<b>3.74***</b>	<b>2.95***</b>	<b>2.73***</b>	<b>2.23***</b>
<i>Anderson-Rubin Wald Chi-sq statistic</i>	<b>25.57***</b>	<b>30.14***</b>	<b>35.72***</b>	<b>44.11***</b>	<b>54.13***</b>
<i>Hansen's J over-identification test</i>	<b>3.75</b>	<b>5.16</b>	<b>6.04</b>	<b>6.82</b>	<b>8.75</b>

**Table 4.8 (Cont'd)**

Panel B: Dependent variable is U.S. Amihud illiquidity

	(1)	(2)	(3)	(4)	(5)
$\widehat{U.S. Short interest}$	<b>-38.08***</b> (10.29)	<b>-37.47***</b> (10.24)	<b>-37.46***</b> (10.24)	<b>-45.56***</b> (11.87)	<b>-45.56***</b> (11.87)
$Short^{US}$	<b>1.23**</b> (0.60)	<b>1.38**</b> (0.66)	<b>1.38**</b> (0.66)	<b>1.03*</b> (0.56)	<b>1.03*</b> (0.56)
$Short^{US} \times \widehat{U.S. Short interest}$	<b>-21.73**</b> (9.52)	<b>-28.09**</b> (12.05)	<b>-28.08**</b> (12.05)	<b>-25.04*</b> (13.37)	<b>-25.05*</b> (13.38)
<i>Toxic</i>		<b>2.22</b> (1.74)		<b>0.87</b> (1.68)	
$Toxic \times \widehat{U.S. Short interest}$		<b>-57.90</b> (35.59)		<b>-31.75</b> (28.29)	
$Toxic \times Short^{US}$		<b>-2.61</b> (2.18)		<b>-1.02</b> (2.30)	
$Toxic \times Short^{US} \times \widehat{U.S. Short interest}$		<b>76.38*</b> (40.33)		<b>54.54</b> (35.58)	
<i>High lending fee</i>				<b>-0.97</b> (2.61)	<b>-0.98</b> (2.61)
$\widehat{High lending fee} \times \widehat{U.S. Short interest}$				<b>25.88</b> (19.24)	<b>25.88</b> (19.24)
$\widehat{High lending fee} \times Short^{US}$				<b>2.46</b> (2.13)	<b>2.46</b> (2.13)
$\widehat{High lending fee} \times Short^{US} \times \widehat{U.S. Short interest}$				<b>-18.10</b> (21.50)	<b>-18.06</b> (21.50)
$\widehat{High lending fee} \times Toxic$				<b>-14.73</b> (9.54)	

**Table 4.8 (Cont'd)**

$High\ lending\ fee \times \widehat{Toxic} \times U.S.Short\ interest$		<b>-459.33*</b>	
		(279.25)	
$High\ lending\ fee \times Toxic \times Short^{US}$		<b>12.47</b>	
		(10.01)	
$High\ lending\ fee \times Toxic \times \widehat{Short}^{US} \times U.S.Short\ interest$		<b>451.68</b>	
		(278.60)	
$Toxic^{down}$	<b>2.98</b>		<b>1.38</b>
	(2.21)		(1.83)
$Toxic^{down} \times \widehat{U.S.Short\ interest}$	<b>-78.27*</b>		<b>-50.65</b>
	(43.45)		(33.96)
$Toxic^{down} \times Short^{US}$	<b>-5.03*</b>		<b>-2.28</b>
	(2.80)		(2.53)
$Toxic^{down} \times \widehat{Short}^{US} \times U.S.Short\ interest$	<b>106.02**</b>		<b>74.25*</b>
	(47.78)		(41.21)
$High\ lending\ fee \times Toxic^{down}$			<b>-9.92**</b>
			(4.94)
$High\ lending\ fee \times Toxic^{down} \times U.S.Short\ interest$			<b>-331.16**</b>
			(146.98)
$High\ lending\ fee \times Toxic^{down} \times Short^{US}$			<b>1.91</b>
			(5.18)
$High\ lending\ fee \times Toxic^{down} \times \widehat{Short}^{US} \times U.S.Short\ interest$			<b>356.83**</b>
			(143.48)
$Toxic^{up}$	<b>1.04</b>		<b>0.14</b>
	(2.93)		(3.28)

**Table 4.8 (Cont'd)**

$Toxic^{up} \times \widehat{U.S. Short interest}$					<b>-25.27</b>	<b>3.94</b>
					(42.82)	(31.31)
$Toxic^{up} \times Short^{US}$					<b>0.06</b>	<b>0.48</b>
					(3.25)	(3.90)
$Toxic^{up} \times Short^{US} \times \widehat{U.S. Short interest}$					<b>33.10</b>	<b>14.67</b>
					(48.38)	(40.33)
$High\ lending\ fee \times Toxic^{up}$						<b>-3.19</b>
						(6.88)
$High\ lending\ fee \times Toxic^{up} \times \widehat{U.S. Short interest}$						<b>98.79</b>
						(147.83)
$High\ lending\ fee \times Toxic^{up} \times Short^{US}$						<b>6.71</b>
						(9.50)
$High\ lending\ fee \times Toxic^{up} \times Short^{US} \times \widehat{U.S. Short interest}$						<b>-145.75</b>
						(163.73)
$U.S. dollar volume$	<b>0.03**</b>	<b>0.03**</b>	<b>0.03**</b>	<b>0.03**</b>	<b>0.03**</b>	<b>0.03**</b>
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
$Ban$	<b>-0.33</b>	<b>-0.38</b>	<b>-0.32</b>	<b>-0.18</b>	<b>-0.18</b>	<b>-0.18</b>
	(1.24)	(1.26)	(1.25)	(1.25)	(1.24)	(1.24)
$VIX$	<b>0.09*</b>	<b>0.09*</b>	<b>0.09*</b>	<b>0.10*</b>	<b>0.10*</b>	<b>0.10*</b>
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
$U.S. volatility$	<b>-0.94</b>	<b>-0.93</b>	<b>-0.93</b>	<b>-0.92</b>	<b>-0.92</b>	<b>-0.92</b>
	(0.81)	(0.81)	(0.81)	(0.79)	(0.79)	(0.79)
$Capitalization$	<b>-3.35***</b>	<b>-3.36***</b>	<b>-3.36***</b>	<b>-3.36***</b>	<b>-3.37***</b>	<b>-3.37***</b>
	(0.88)	(0.88)	(0.88)	(0.90)	(0.90)	(0.90)
$U.S. 1/price$	<b>5.44</b>	<b>5.41</b>	<b>5.44</b>	<b>5.49</b>	<b>5.49</b>	<b>5.49</b>
	(5.23)	(5.22)	(5.22)	(5.11)	(5.11)	(5.11)
$Constant$	<b>27.35***</b>	<b>27.38***</b>	<b>27.37***</b>	<b>27.45***</b>	<b>27.46***</b>	<b>27.46***</b>
	(7.24)	(7.25)	(7.25)	(7.53)	(7.54)	(7.54)

**Table 4.8 (Cont'd)**

	Yes	Yes	Yes	Yes	Yes
<i>Firm fixed effects</i>					
<i>Number of observations</i>	23,453	23,453	23,453	23,453	23,453
<i>R<sup>2</sup> (within)</i>	0.14	0.14	0.14	0.12	0.13
<i>Anderson-Rubin Wald F statistic</i>	<b>4.82***</b>	<b>3.37***</b>	<b>2.41***</b>	<b>2.10***</b>	<b>2.41***</b>
<i>Anderson-Rubin Wald Chi-sq statistic</i>	<b>19.45***</b>	<b>27.19***</b>	<b>29.16***</b>	<b>33.92***</b>	<b>58.49***</b>
<i>Hansen's J over-identification test</i>	<b>1.91</b>	<b>3.54</b>	<b>5.83</b>	<b>6.94</b>	<b>14.25</b>

**Table 4.9: Robustness tests– full time-series estimation**

This table presents the effect of short sales on the liquidity in cross-listing arbitrage opportunities with full time-series estimation. Our sample includes 134 Canadian stocks that are cross-listed in the U.S. between July 2006 and December 2013. The estimation equations are similar to that in Table 4, 5 and 6. Panel A uses *percent quoted spread* as the liquidity measure. Panel B uses *Amihud illiquidity* as the liquidity measure. Variables are as defined in previous tables. Standard errors (reported in parentheses) are clustered by firm. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Dependent variable is U.S. percent quoted spread

	(1)	(2)	(3)	(4)	(5)
<i>U.S. short interest</i>	<b>-10.51**</b> (4.15)	<b>-10.51**</b> (4.15)	<b>-10.51**</b> (4.15)	<b>-6.28</b> (4.06)	<b>-6.29</b> (4.06)
<i>Short<sup>US</sup></i>	<b>6.25***</b> (1.24)	<b>6.01***</b> (1.39)	<b>6.01***</b> (1.38)	<b>1.44</b> (1.03)	<b>1.44</b> (1.03)
<i>Short<sup>US</sup> × U.S. short interest</i>	<b>-26.90***</b> (9.05)	<b>-25.88**</b> (10.59)	<b>-25.89**</b> (10.60)	<b>-13.48</b> (9.29)	<b>-13.50</b> (9.29)
<i>Toxic</i>		<b>2.06</b> (2.70)		<b>0.13</b> (2.36)	
<i>Toxic × U.S. short interest</i>		<b>-26.34</b> (16.31)		<b>-16.80</b> (15.30)	
<i>Toxic × Short<sup>US</sup></i>		<b>-1.16</b> (3.15)		<b>3.65</b> (2.63)	
<i>Toxic × Short<sup>US</sup> × U.S. short interest</i>		<b>22.79</b> (20.38)		<b>-2.10</b> (17.92)	
<i>High lending fee</i>				<b>2.38*</b> (1.35)	<b>2.37*</b> (1.35)
<i>High lending fee × U.S. short interest</i>				<b>-15.87</b> (12.14)	<b>-15.86</b> (12.13)
<i>High lending fee × Short<sup>US</sup></i>				<b>17.01***</b> (4.21)	<b>17.01***</b> (4.21)
<i>High lending fee × Short<sup>US</sup> × U.S. short interest</i>				<b>-28.77</b> (18.47)	<b>-28.77</b> (18.47)
<i>High lending fee × Toxic</i>				<b>8.08***</b> (3.00)	

**Table 4.9 (Cont'd)**

<i>High lending fee</i> × <i>Toxic</i> × <i>U.S. short interest</i>		<b>-44.04**</b> (18.31)	
<i>High lending fee</i> × <i>Toxic</i> × <i>Short</i> <sup>US</sup>		<b>-18.05***</b> (6.22)	
<i>High lending fee</i> × <i>Toxic</i> × <i>Short</i> <sup>US</sup> × <i>U.S. short interest</i>		<b>91.96***</b> (33.48)	
<i>Toxic</i> <sup>down</sup>	<b>2.87</b> (3.80)		<b>-0.41</b> (3.28)
<i>Toxic</i> <sup>down</sup> × <i>U.S. short interest</i>	<b>-47.07**</b> (22.28)		<b>-30.91</b> (20.50)
<i>Toxic</i> <sup>down</sup> × <i>Short</i> <sup>US</sup>	<b>-2.88</b> (4.21)		<b>3.72</b> (4.00)
<i>Toxic</i> <sup>down</sup> × <i>Short</i> <sup>US</sup> × <i>U.S. short interest</i>	<b>51.40*</b> (27.63)		<b>11.62</b> (25.74)
<i>High lending fee</i> × <i>Toxic</i> <sup>down</sup>			<b>13.96***</b> (4.03)
<i>High lending fee</i> × <i>Toxic</i> <sup>down</sup> × <i>U.S. short interest</i>			<b>-49.86**</b> (19.78)
<i>High lending fee</i> × <i>Toxic</i> <sup>down</sup> × <i>Short</i> <sup>US</sup>			<b>-26.19***</b> (6.88)
<i>High lending fee</i> × <i>Toxic</i> <sup>down</sup> × <i>Short</i> <sup>US</sup> × <i>U.S. short interest</i>			<b>121.83***</b> (36.18)
<i>Toxic</i> <sup>up</sup>	<b>0.77</b> (1.82)		<b>1.55</b> (1.80)
<i>Toxic</i> <sup>up</sup> × <i>U.S. short interest</i>	<b>0.21</b> (15.00)		<b>-3.54</b> (15.72)
<i>Toxic</i> <sup>up</sup> × <i>Short</i> <sup>US</sup>	<b>1.13</b> (3.20)		<b>2.61</b> (2.49)
<i>Toxic</i> <sup>up</sup> × <i>Short</i> <sup>US</sup> × <i>U.S. short interest</i>	<b>-17.59</b> (21.96)		<b>-13.97</b> (20.96)
<i>High lending fee</i> × <i>Toxic</i> <sup>up</sup>			<b>-3.08</b> (5.20)

**Table 4.9 (Cont'd)**

<i>High lending fee</i> × <i>Toxic</i> <sup>HP</sup> × <i>U.S. short interest</i>					<b>5.96</b> (56.25)
<i>High lending fee</i> × <i>Toxic</i> <sup>HP</sup> × <i>Short</i> <sup>US</sup>					<b>-3.63</b> (10.15)
<i>High lending fee</i> × <i>Toxic</i> <sup>HP</sup> × <i>Short</i> <sup>US</sup> × <i>U.S. short interest</i>					<b>-21.85</b> (63.18)
<i>Short</i> <sup>CA</sup>	<b>1.67**</b> (0.80)	<b>1.03</b> (1.01)	<b>1.03</b> (1.01)	<b>1.05</b> (1.02)	<b>1.05</b> (1.02)
<i>Short</i> <sup>CA</sup> × <i>U.S. short interest</i>	<b>-8.82</b> (7.02)	<b>-1.01</b> (8.89)	<b>-1.00</b> (8.89)	<b>-1.85</b> (9.01)	<b>-1.86</b> (9.01)
<i>U.S. dollar volume</i>	<b>0.07***</b> (0.02)	<b>0.07***</b> (0.02)	<b>0.07***</b> (0.02)	<b>0.06***</b> (0.02)	<b>0.06***</b> (0.02)
<i>Ban</i>	<b>9.11***</b> (2.73)	<b>9.03***</b> (2.73)	<b>9.04***</b> (2.73)	<b>9.02***</b> (2.68)	<b>9.13***</b> (2.67)
<i>VIX</i>	<b>0.27***</b> (0.08)	<b>0.27***</b> (0.08)	<b>0.27***</b> (0.08)	<b>0.28***</b> (0.09)	<b>0.28***</b> (0.09)
<i>U.S. volatility</i>	<b>-0.58</b> (1.13)	<b>-0.58</b> (1.13)	<b>-0.58</b> (1.13)	<b>-0.49</b> (1.10)	<b>-0.49</b> (1.10)
<i>Capitalization</i>	<b>-12.73**</b> (5.42)	<b>-12.73**</b> (5.42)	<b>-12.73**</b> (5.42)	<b>-12.55**</b> (5.42)	<b>-12.55**</b> (5.42)
<i>U.S. 1/price</i>	<b>103.55***</b> (19.61)	<b>103.54***</b> (19.60)	<b>103.53***</b> (19.60)	<b>103.25***</b> (19.54)	<b>103.26***</b> (19.54)
<i>Constant</i>	<b>110.19***</b> (41.58)	<b>110.18***</b> (41.57)	<b>110.22***</b> (41.57)	<b>107.68**</b> (41.68)	<b>107.67**</b> (41.66)
<i>Firm fixed effects</i>	Yes	Yes	Yes	Yes	Yes
<i>Number of observations</i>	129,163	129,163	129,163	129,163	129,163
<i>R</i> <sup>2</sup> (within)	0.36	0.36	0.36	0.36	0.36



**Table 4.9 (Cont'd)**

Panel B: Dependent variable is U.S. Amihud illiquidity

	(1)	(2)	(3)	(4)	(5)
<i>U.S. short interest</i>	<b>-2.64</b> (1.61)	<b>-2.64</b> (1.61)	<b>-2.63</b> (1.60)	<b>-0.99</b> (1.59)	<b>-1.00</b> (1.59)
<i>Short<sup>US</sup></i>	<b>1.71***</b> (0.60)	<b>2.01***</b> (0.71)	<b>2.01***</b> (0.71)	<b>0.19</b> (0.48)	<b>0.20</b> (0.48)
<i>Short<sup>US</sup> × U.S. short interest</i>	<b>-9.36***</b> (3.53)	<b>-10.56**</b> (4.72)	<b>-10.56**</b> (4.72)	<b>-6.67**</b> (3.06)	<b>-6.67**</b> (3.06)
<i>Toxic</i>		<b>1.24</b> (1.36)		<b>0.04</b> (1.11)	
<i>Toxic × U.S. short interest</i>		<b>-3.86</b> (8.09)		<b>2.71</b> (7.46)	
<i>Toxic × Short<sup>US</sup></i>		<b>-2.33</b> (1.58)		<b>0.44</b> (1.34)	
<i>Toxic × Short<sup>US</sup> × U.S. short interest</i>		<b>8.08</b> (9.83)		<b>-3.40</b> (8.30)	
<i>High lending fee</i>				<b>0.63</b> (0.69)	<b>0.62</b> (0.69)
<i>High lending fee × U.S. short interest</i>				<b>-6.20</b> (4.76)	<b>-6.20</b> (4.75)
<i>High lending fee × Short<sup>US</sup></i>				<b>6.83***</b> (2.13)	<b>6.83***</b> (2.13)
<i>High lending fee × Short<sup>US</sup> × U.S. short interest</i>				<b>-8.05</b> (13.38)	<b>-8.04</b> (13.38)
<i>High lending fee × Toxic</i>				<b>5.08**</b> (2.16)	

**Table 4.9 (Cont'd)**

<i>High lending fee</i> $\times$ <i>Toxic</i> $\times$ <i>U.S. short interest</i>		<b>-32.46***</b> (11.92)	
<i>High lending fee</i> $\times$ <i>Toxic</i> $\times$ <i>Short</i> <sup>US</sup>		<b>-10.85***</b> (3.93)	
<i>High lending fee</i> $\times$ <i>Toxic</i> $\times$ <i>Short</i> <sup>US</sup> $\times$ <i>U.S. short interest</i>		<b>45.36**</b> (22.25)	
<i>Toxic</i> <sup>down</sup>	<b>2.79</b> (1.88)		<b>0.69</b> (1.53)
<i>Toxic</i> <sup>down</sup> $\times$ <i>U.S. short interest</i>	<b>-13.57</b> (11.79)		<b>-1.43</b> (11.20)
<i>Toxic</i> <sup>down</sup> $\times$ <i>Short</i> <sup>US</sup>	<b>-5.43**</b> (2.18)		<b>-0.91</b> (1.68)
<i>Toxic</i> <sup>down</sup> $\times$ <i>Short</i> <sup>US</sup> $\times$ <i>U.S. short interest</i>	<b>23.35*</b> (12.41)		<b>2.71</b> (11.63)
<i>High lending fee</i> $\times$ <i>Toxic</i> <sup>down</sup>			<b>8.98***</b> (2.46)
<i>High lending fee</i> $\times$ <i>Toxic</i> <sup>down</sup> $\times$ <i>U.S. short interest</i>			<b>-42.36***</b> (13.28)
<i>High lending fee</i> $\times$ <i>Toxic</i> <sup>down</sup> $\times$ <i>Short</i> <sup>US</sup>			<b>-17.88***</b> (4.67)
<i>High lending fee</i> $\times$ <i>Toxic</i> <sup>down</sup> $\times$ <i>Short</i> <sup>US</sup> $\times$ <i>U.S. short interest</i>			<b>65.51***</b> (22.97)
<i>Toxic</i> <sup>up</sup>	<b>-1.72*</b> (1.01)		<b>-1.22</b> (1.32)

**Table 4.9 (Cont'd)**

$Toxic^{up} \times U.S. \text{ short interest}$			<b>10.14</b>		<b>8.15</b>
			(6.97)		(7.76)
$Toxic^{up} \times Short^{US}$			<b>2.16</b>		<b>2.32</b>
			(1.67)		(2.14)
$Toxic^{up} \times Short^{US} \times U.S. \text{ short interest}$			<b>-13.99</b>		<b>-11.17</b>
			(11.62)		(12.10)
$High \text{ lending fee} \times Toxic^{up}$					<b>-1.96</b>
					(2.89)
$High \text{ lending fee} \times Toxic^{up} \times U.S. \text{ short interest}$					<b>2.47</b>
					(17.82)
$High \text{ lending fee} \times Toxic^{up} \times Short^{US}$					<b>0.38</b>
					(4.91)
$High \text{ lending fee} \times Toxic^{up} \times Short^{US} \times U.S. \text{ short interest}$					<b>-7.88</b>
					(32.62)
$Short^{CA}$	<b>2.23***</b>	<b>1.84***</b>	<b>1.85***</b>	<b>1.84***</b>	<b>1.85***</b>
	(0.76)	(0.66)	(0.67)	(0.66)	(0.67)
$Short^{CA} \times U.S. \text{ short interest}$	<b>-10.15***</b>	<b>-8.95**</b>	<b>-8.95**</b>	<b>-9.28**</b>	<b>-9.28**</b>
	(3.86)	(4.39)	(4.39)	(4.42)	(4.42)
$U.S. \text{ dollar volume}$	<b>0.03***</b>	<b>0.03***</b>	<b>0.03***</b>	<b>0.03***</b>	<b>0.03***</b>
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
$Ban$	<b>0.87</b>	<b>0.85</b>	<b>0.86</b>	<b>0.85</b>	<b>0.89</b>
	(1.09)	(1.11)	(1.12)	(1.08)	(1.09)
$VIX$	<b>0.06</b>	<b>0.06</b>	<b>0.06</b>	<b>0.06</b>	<b>0.06</b>
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
$U.S. \text{ volatility}$	<b>-0.58</b>	<b>-0.58</b>	<b>-0.58</b>	<b>-0.55</b>	<b>-0.55</b>
	(0.49)	(0.50)	(0.50)	(0.48)	(0.48)
$Capitalization$	<b>-3.42</b>	<b>-3.42</b>	<b>-3.42</b>	<b>-3.37</b>	<b>-3.37</b>
	(2.09)	(2.09)	(2.09)	(2.11)	(2.11)

**Table 4.9 (Cont'd)**

<i>U.S. 1/price</i>	<b>24.36***</b> (8.97)	<b>24.36***</b> (8.97)	<b>24.35***</b> (8.97)	<b>24.24***</b> (8.93)	<b>24.26***</b> (8.94)
<i>Constant</i>	<b>26.10</b> (15.92)	<b>26.08</b> (15.91)	<b>26.11</b> (15.92)	<b>25.42</b> (16.12)	<b>25.40</b> (16.13)
<i>Firm fixed effects</i>	Yes	Yes	Yes	Yes	Yes
<i>Number of observations</i>	128,984	128,984	128,984	128,984	128,984
<i>R<sup>2</sup> (within)</i>	0.08	0.08	0.08	0.08	0.08

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