# Funding liquidity and equity liquidity in the subprime crisis period: Evidence from the ETF market

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## ARTICLE INFO

## ABSTRACT

Using index and financial exchange-traded funds (ETFs), this study explores the relation between funding liquidity and equity liquidity during the subprime crisis period. Our empirical results show that a higher degree of funding illiquidity leads to an increase in bid–ask spread and a reduction in both market depth and net buying imbalance. Such findings indicate that an increase in funding liquidity can improve equity liquidity, with a stronger effect for the financial ETFs than for the index ETFs. Our study provides a better overall understanding of the effect of the liquidity–supplier funding constraint during the subprime crisis period.

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## 1. Introduction

The issue of funding constraints on liquidity suppliers has received considerable attention within the recent literature. The continuous arrival of bad news or a sentiment of uncertainty within the market can clearly result in redemption pressure from retail investors on liquidity suppliers (e.g., intermediaries, speculators, and arbitrageurs). They therefore may be faced with funding constraints as well as the risk of higher margins. These funding problems can potentially cause them to withdraw from their roles of correcting mispricing and providing liquidity to the market (Shleifer and Vishny, 1997). As a result, liquidity suppliers can instead become short-term liquidity demanders, rushing to liquidate their positions following negative shocks and thereby causing equity illiquidity and further price declines.[1]

Both Kyle and Xiong (2001) and Gromb and Vayanos (2002) argue from a theoretical perspective that if arbitrageurs exhibit a reduction in their previous level of risk aversion or are faced with funding constraints, they may essentially change to liquidity demanders, liquidating their positions in risky assets to establish funding inflows and thereby further widening the price wedge. Building a model that links the market and funding liquidity, Brunnermeier and Pedersen (2009) argue that liquidity spirals that are triggered by a large liquidity shock result in larger margin requirements and thus losses on existing positions. These losses restrict the ability of dealers to provide further equity liquidity.

This study explores the relation between funding liquidity and equity liquidity during the subprime crisis period using index and financial exchange-traded funds (ETFs). The extreme variations in funding and equity liquidity that were evident during the subprime crisis period provide a valuable opportunity to examine the ways in which funding constraints affect equity liquidity. Such a situation is useful not only to academics but also practitioners, as the related reports are easily available from the major

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[1] Brunnermeier (2009) posits that funding constraint problems affecting liquidity may not be binding in terms of causing liquidity spirals to arise, because the funding problems affecting liquidity levels may simply be attributable to arbitrage limits.

media suppliers such as the *Wall Street Journal*.[2] Our study provides a better overall understanding of the effect of the liquidity–supplier funding constraint during the subprime crisis period.

The liquidity crisis began in early 2007 as a result of a sharp increase in subprime mortgage defaults (Claessens et al., 2009). Given the continuous flow of news on defaults and write-downs, financial intermediaries were faced with huge redemption pressure from retail investors; the resultant funding problem for the various financial intermediaries led them to seek financing from the short-term collateral market (e.g., asset-backed commercial paper (ABCP) and Repo). With investors deciding not to reinvest their proceeds on the maturity of their collateral, liquidity within the collateral market essentially dried up, which made it extremely difficult for the financial intermediaries to roll over their short-term liabilities.

Although many of the financial intermediaries had strong back-up liquidity lines from banks, without greater knowledge on the potential risk involved and their own imminent liquidity needs, banks were unwilling to engage in interbank lending during the subprime crisis (with the exception of instruments with very short-term maturities, such as overnight to 1 week). Questions on counterparty insolvency also ensured continuing illiquidity in the interbank markets. When hedge funds and financial intermediaries found it difficult to roll over their short-term liabilities from both the collateral and interbank markets, financial intermediaries began to sell more liquid assets from their existing portfolios to meet their funding constraints. However, because many of the structured financial products were also suffering from illiquidity, such that no reliable price existed, they would, of course, have preferred to sell assets with higher market liquidity first (Brunnermeier, 2009). As a result, the equity liquidity of the more liquid assets was reduced still further.

In addition to the theoretical studies previously discussed, recent empirical studies reveal an increased focus on the effects of liquidity constraints. Frank et al. (2008) examine the ways in which liquidity shocks are transmitted across multiple financial markets and countries between 2006 and 2007. They find that the relation between the market and funding liquidity in the US market becomes increasingly stronger during the 2007 subprime crisis period. Specifically, they show that the funding liquidity pressure from the US interbank money market and the ABCP market is transmitted to other advanced economies. However, clearly, the transmission of the US liquidity shock to the emerging markets is largely the result of market liquidity pressure. Using a unique data set on NYSE specialist inventory positions and trading revenue, Comerton-Forde et al. (2010) find that the financing constraints of liquidity suppliers are a matter of real concern.

Hameed et al. (2010) use a sample of NYSE-listed stocks, covering the period from January 1998 to December 2003, to explore the relation between the market decline and the liquidity drought as an indicator of capital constraints in the marketplace. Their results show that a reduction in market liquidity following a market decline is closely related to the tightness of funding liquidity, because a large negative return can reduce the investor capital tied to mar-

ketable securities. Thus, funding problems from negative returns can result in a reduction in the level of liquidity provision into the market by investors, and, as a result, market illiquidity increases. Hameed et al. (2010) also use funding liquidity measures, such as the commercial paper spread to capture the willingness among financial intermediaries to provide liquidity and finds that an increase in funding illiquidity during a period of decline in the market can lead to a more significant increase proportional bid–ask spread and deterioration in equity liquidity.[3]

Our study adds several findings to the extant literature on the ways in which funding liquidity affects equity liquidity. First, although our study and the work of Hameed et al. (2010) is closely related, we focus on the extreme variations in funding and equity liquidity during the subprime crisis period because funding constraints have more significant effects on the trading behavior and liquidity provision of investors under extreme conditions.

Second, unlike Hameed et al. (2010), who undertake only an indirect exploration of the effect of funding liquidity on equity liquidity during a period of market decline, we directly examine the ways in which funding liquidity affects equity liquidity. We note that liquidity shocks, the announcements of bad news, and investor sentiment based on uncertainty can all lead investors to redeem their shares, resulting in an increase in precautionary hoarding by banks that can clearly create funding problems for financial intermediaries (Brunnermeier, 2009). Therefore, not only market decline but also other reasons can potentially lead to funding illiquidity.

Third, because equity liquidity includes price and volume dimensions (Lee et al., 1993), we explore the ways in which funding liquidity affects bid–ask spread and market depth. This approach provides a more comprehensive analysis than prior empirical studies. In sum, we examine the ways in which funding liquidity affects the bid–ask spread, market depth, and net buying imbalance for both the index and financial ETFs markets during the subprime crisis period.[4]

Many of the recent empirical studies use funding liquidity to measure the situation among funding liquidity suppliers. However, because we do not have access to direct measures of the aggregate liquidity suppliers providing such liquidity, we use measures based on funding costs. We take the funding costs in both the interbank and collateral markets as proxies for the funding situation of liquidity suppliers. The interbank market reveals hoarding in the lending channel, and the collateral market shows the level of deterioration in the borrowers' balance sheet. Prior literature supports this approach. Specifically, Frank et al. (2008) show that funding liquidity pressures could come from interbank and ABCP markets, and Brunnermeier (2009) argues that banks often use repo and interbank markets to finance themselves. In addition, Hameed et al. (2010) suggest that using the funding cost indicators from financial sector could measure funding constrained of liquidity providers.

We use ETF data for the following reasons. First, ETFs are usually more liquid and therefore more suited to our research question as funding problems can lead to financial intermediaries liquidating the more liquid assets from their portfolios as a first step (Brunnermeier, 2009). Second, we also focus on the financial ETF markets because the financial industry is the sector most directly affected by the subprime crisis. Using financial ETFs on various financial subgroups, we can examine whether different types of financial ETFs reveal different relations between equity liquidity

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[2] For example, the *Wall Street Journal* reported: "Hedge funds are selling billions of dollars of securities to meet demands for cash from their investors and their lenders, contributing to the stock market's nearly 10% drop over the past two days" (Strasburg and Zuckerman, 2008). The *Wall Street Journal* also reported: "Some hedge fund managers are coming under increasing pressure to liquidate their positions as banks ask for more collateral to back funds' borrowing...Many investors and regulators worry whether a broad hedge-fund deleveraging will create more risk for the overall financial system...Levels of market exposure have decreased by over one-third in the past 12 months, according to Hedge Fund Research Inc., as managers hold more cash to meet investor withdrawals and to keep losses in check. Funds held a record $184 billion of cash as of August, according to Merrill Lynch, about 10% of the funds' assets" (Zuckerman and Bryan-Low, 2008).

[3] Other studies also argue that the funding constraints play important roles in convertible and merger events (Mitchell et al., 2007), bank runs (Bernado and Welch, 2004) and risk management (Garleanu and Pedersen, 2007).

[4] We divide the financial ETFs into five groups (broad financial sector, banks, brokerage and asset management, insurance, and global).

and funding liquidity. A majority of prior studies generally tends to use daily or even lower frequency, data. However, lower frequency data may not be capable of detecting the interactive relation between equity liquidity and funding liquidity, particularly if it occurs for relatively short periods of time and is masked by the aggregate nature of the data. Thus, we use higher frequency intraday data, which allow us to draw more precise inferences.

Our empirical findings are summarized as follows. First, our results show that higher funding illiquidity leads to an increase in bid–ask spread and a reduction in market depth, which indicates that an increase in funding liquidity can improve equity liquidity. Second, we find that with a decline in funding liquidity, investors tend to place more sell orders, which leads to a reduction in net buying imbalance. However, these results are weaker than those for bid–ask spread and market depth. Third, our results generally reveal that the interbank market funding liquidity measure has a more significant impact than the collateral market funding liquidity measure on both equity liquidity and net buying imbalance. We find that when funding liquidity changes, the impact on both the liquidity and net buying imbalance of financial ETFs is more significant than that of index ETFs. Our results on the various financial subgroup ETFs show that a higher degree of funding illiquidity leads to an increase in bid–ask spread for the brokerage and asset management group.

The remainder of this paper is organized as follows. Section 2 provides a description of the data and the research methodology. The section also develops our testable hypotheses. Section 3 presents and analyzes our empirical results. Finally, Section 4 offers the conclusions drawn from this study.

## 2. Data and research methodology

### 2.1. Data source and sample selection

We use index and financial ETFs to explore the relation between funding liquidity and equity liquidity. For our empirical examination of index ETFs, we select those funds tracking the S&P 500 Index (SPY) and those funds tracking the NASDAQ 100 Index (QQQQ). We also examine 14 financial ETFs, the average daily trading volume of which must be higher than 11,000 units from January 1, 2007 to December 31, 2008, and then divide them into five groups.[5] In the overall US financial sector group, the underlying index includes broad financial business in the United States, such as commercial and investment banking, capital markets, diversified financial services, insurance, and real estate. In the banking group, the underlying index includes national money center banks and regional banking institutions listed on the US stock markets.

In the brokerage and asset management group, the underlying index includes securities brokers and dealers, online brokers, asset managers, and securities or commodities exchanges. The insurance industry consists of personal and commercial lines, property/casualty, life insurance, reinsurance, brokerage, and financial guarantees. Finally, for the global group, the underlying index includes major financial companies in the markets outside of the United States and Canada.

We employ intraday data on ETFs taken from the NYSE Trade and Quote (TAQ) database, using the daily abstract trade and quote data from 9:30 am to 4:00 pm. We include all of the data in the AMEX, NYSE, NYSE Arca, NASDAQ, NASDAQ (ADF), and National Stock Exchanges, following the prior literature to control for different trading mechanisms. The period under examination is the postdecimalization period, which runs from January 1, 2007 to December 31, 2008 (i.e., a period that contains the subprime mortgage

crisis period). All days with no trading volume data are excluded from our research samples.

We follow Chung and Van Ness (2001) to eliminate all quotes that meet any of the following three conditions: (a) either the bid or the ask price is equal to or less than zero, (b) either the bid or the ask depth is equal to or less than zero, or (c) either the price or volume is equal to or less than zero. We also follow Huang and Stoll (1996) to filter out all trade and quote data with the following characteristics: (a) all quotes with a negative bid–ask spread or a bid–ask spread of greater than US$5; (b) all trades and quotes at either "before-the-open" or "after-the close"; (c) all of the $P_t$ trade prices, where $|(P_t - P_{t-1})/P_{t-1}| > 0.1$; (d) all of the $a_t$ ask quotes, where $|(a_t - a_{t-1})/a_{t-1}| > 0.1$; and (e) all of the $b_t$ bid quotes, where $|(b_t - b_{t-1})/b_{t-1}| > 0.1$.

### 2.2. Funding liquidity measures

We follow Brunnermeier (2009) to construct our funding liquidity measures. We use the interbank market to measure hoarding in the lending channel and the collateral market to measure deterioration in the borrowers' balance sheets. We then employ the daily funding variable, which we take from the Bloomberg database. In the interbank market, we use *Libor*, modeled as the spread between the 3-month US interbank Libor rate and the overnight index swap, to measure the capital constraints of the financial intermediaries.[6] In the collateral markets, we use *ABCP*, measured as the spread between the 3-month *ABCP* rates and the overnight index swap, and *Repo*, calculated as the mortgage repossession rate minus the government repossession rate,[7] to capture hedge funds and the capital constraints of market makers.[8]

### 2.3. Measure of equity liquidity

#### 2.3.1. Bid–ask spread

We use percentage spread as the illiquidity variable, which is calculated as $(Ask_t - Bid_t)/[(Ask_t + Bid_t)/2] \times 100$; where $Ask_t$ ($Bid_t$) is the intraday ask (bid) price at time $t$ (see Berkman and Nguyen, 2010; Kryzanowski et al., 2010). We then calculate the average of all the percentage spreads in one day. To control for the factors that may be important in determining the spread, we follow Barclay (1997), Copeland and Galai (1983), and Stoll (2000) to investigate the following regression model:

$$Spread_{it} = \alpha + \beta_1 Ret_{it} + \beta_2 Vol_{it} + \beta_3 LogV_{it} + \beta_4 Spread_{it-1} + \beta_5 D_{short} + \beta_6 Funding_t + \varepsilon_{it}, \tag{1}$$

where $Spread_{it}$ is the average daily percentage spread for ETF $i$ on day $t$; $Ret_{it}$ is the daily return for ETF $i$ on day $t$; $Vol_{it}$ is the daily Parkinson volatility for ETF $i$ on day $t$; $V_{it}$ is the daily trading volume for ETF $i$ on day $t$; $Spread_{it-1}$ is the average daily percentage spread for ETF $i$ on day $t - 1$; and $D_{short}$ is a dummy variable that equals 1 from September 17, 2008 to October 17, 2008, a period when the US Securities and Exchange Commission prohibited short sales of financial company stocks. *Funding* is the daily funding liquidity, which is measured by *Libor*, *ABCP*, and *Repo*, where *Libor* is the spread between the 3-month US interbank Libor rate and the

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[5] The details on our research samples are provided in the Appendix.

[6] See Kotomin et al. (2008), Baba and Packer (2009), and Fong et al. (2010), each of which uses the spread between the Libor rate and overnight index swap to measure funding liquidity.

[7] Adrian and Shin (2008), Frank et al. (2008), and Hameed et al. (2010) also use funding liquidity measures from ABCP and repo markets.

[8] We also use the spread between the 3-month US Treasury bills and the Eurodollar Libor rate (i.e., the TED ratio) and the spread between the 3-month US Treasury bills and the overnight index swap to test the robustness of our empirical results. The results are similar to those reported in the main findings. We do not report the results of the robustness check for the sake of brevity; these results are, however, available on request.

overnight index swap on day $t$; *ABCP* is the spread between the 3-month ABCP rates and the overnight index swap on day $t$; and *Repo* is the spread between the mortgage repossession rates minus the government repossession rate on day $t$.

We argue that with an increase in the financing costs of investors (*Libor*, *ABCP*, and *Repo*), funding problems will induce liquidity suppliers to provide less liquidity and to become short-term liquidity demanders. This increase in demand for liquidity would result in a reduction (increase) in equity liquidity (bid–ask spread). We therefore hypothesize that lower funding liquidity leads to a larger bid–ask spread and lower equity liquidity.

### 2.3.2. Market depth

Equity liquidity has both a price dimension (spread) and a quantity dimension (depth). Lee et al. (1993) argue that liquidity providers are sensitive to changes in information asymmetry risk and that they use both spread and depth to actively manage this risk. Following Brockman and Chung (1999), who argue that dollar depth provides a more relevant measure of liquidity, we define depth as the number of shares at the best bid and ask price multiplied by their respective prices and then take the average of each depth on date $t$ as our depth variable. Finally, we divide the market depth by 100 to reduce the size of the variable.

Thus, our market depth variable is the daily dollar depth, which, from the perspective of investors, is a more relevant measure of liquidity than the alternative measure based solely on the available number of shares. We follow Ahn et al. (2001) to control for the factors that may be of importance in determining market depth by examining the relation between market depth and funding liquidity in the following regression model:

$$Depth_{it} = \alpha + \beta_1 Vol_{it} + \beta_2 Ntrade_{it} + \beta_3 Depth_{it-1} + \beta_4 D_{short} + \beta_5 Funding_t + \varepsilon_{it}, \qquad (2)$$

where $Depth_{it}$ is the daily average of the market depth for ETF $i$ on day $t$; $Depth_{it-1}$ is the daily average of the market depth for ETF $i$ on day $t-1$; and $Ntrade_{it}$ is the daily number of trades for ETF $i$ on day $t$.[9]

The huge losses from the subprime sector and the fall in housing prices during the subprime crisis period resulted in a serious funding problem for investors. To profit quickly from their portfolios to resolve their funding problems, investors chose to increase their market orders and reduce their limit orders, resulting in an increase in liquidity demanders and a reduction in market depth. Many studies have also shown a negative association between the two dimensions of the liquidity pattern; that is, the wider (narrower) the spread, the smaller (larger) the depth.[10] Based on a similar argument, we suggest that a lower level of funding liquidity results in a reduction in market depth.

### 2.3.3. Net buying imbalance

From the theoretical perspective, Kyle and Xiong (2001) and Gromb and Vayanos (2002) both argue that when arbitrageurs face funding constraints, they may withdraw from their role as liquidity providers and instead become liquidity demanders, selling their positions to resolve their funding problem. As a result, stock price and liquidity further reduce. Therefore, in this portion of the analysis, we use net buying imbalance to measure investor net selling pressure to determine whether investors may, in fact, choose to sell more and buy less to reduce their funding constraints when they have a funding problem. This investigation allows us to examine the effects of funding liquidity on the trading behavior of investors. For our calculation of net buying imbalance, we use the

algorithm proposed by Lee and Ready (1991) to determine whether the transactions are buyer or seller initiated. The algorithm classifies a trade as a buyer (seller) initiated trade if the traded price is higher (lower) than the midpoint of the bid and ask price. We assign a value of +1 ($-1$) to each transaction to indicate that the trade is buyer (seller) initiated and multiply the assigned value by trading dollar. To obtain the net buying imbalance for each trading day, we sum all of the multiplication results that occur on each day and divide the daily net buying imbalance by 100,000.[11]

In addition, following Bailey et al. (2000) and Chung (2006), we add volume and return variables as control variables in our regression model to control for the possibility that trade initiations may be dependent on returns and volume. The relation between net buying imbalance and funding liquidity is explored in the following model:

$$OIBDOL_{it} = \alpha + \beta_1 Ret_{it} + \beta_2 Ret_{it-1} + \beta_3 Vol_{it} + \beta_4 LogV_{it} + \beta_5 OIBDOL_{it-1} + \beta_6 D_{short} + \beta_7 Funding_t + \varepsilon_{it}, \qquad (3)$$

where $OIBDOL_{it}$ is the net buying imbalance variable (buyer-initiated dollars paid less seller-initiated dollars received) for ETF $i$ on day $t$, and $OIBDOL_{it-1}$ is the net buying imbalance variable for ETF $i$ on day $t-1$.[12]

With an increase in the financing costs of investors, the liquidity suppliers provide less liquidity, resulting in a more volatile market. The resultant funding problems for investors may cause them to buy fewer stocks or sell off their securities holdings to profit from their positions. We therefore argue that lower funding liquidity causes a reduction in net buying imbalance.[13]

For all the model specifications (i.e., Eqs. (1)–(3)), we use a panel data regression framework to investigate the effects of funding liquidity on equity liquidity. We perform the Hausman test on all of our empirical models. We find no misspecification from the use of the random effects model; this model is therefore selected for the estimation of all of our empirical models. We also follow the method of Wansbeek and Kapteyn (1989),[14] which we use to handle both balanced and unbalanced data.

We also apply the Parks (1967) method to estimate a pooled cross-sectional time series regression, which corrects for heteroscedasticity and first-order autocorrelation. Because Kim and Ogden (1996) find higher order serial correlation for the spread, the Parks approach provides consistent and efficient estimates of the parameters when disturbances follow a first-order autoregressive process, AR(1), with contemporaneous correlation.[15] Because the Parks method requires balance panel data, we delete the data on the trading days of April 4, 2007, April 17, 2007, and May, 7 2007. The results of the Parks method are similar to those reported for the random effects model.[16]

## 3. Empirical results

### 3.1. Descriptive statistics

Table 1 provides the descriptive statistics of our study sample. For the full sample, the mean *Spread*, *Depth*, and *OIBDOL* are 0.2501, 75.94, and 49.51, respectively. We further separate the

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[9] The remaining control variables are the same as those in Eq. (1).
[10] See Lee et al. (1993) and Brockman and Chung (1999).

[11] See Chordia et al. (2002).
[12] The remaining control variables are the same as those in Eq. (1).
[13] We also examine whether funding illiquidity has impacts on the net buying volume and find that the results of net buying volume are similar to the reported net buying imbalance results; thus, for the purpose of brevity, they are not reported here. These results are, however, available on request.
[14] See the SAS PANEL procedure.
[15] See Chordia and Subrahmanyam (2004) and Greene (2008).
[16] The results are not reported here for the sake of brevity; they are, however, available on request.

**Table 1**
Descriptive statistics.

| Variables | Mean | Median | SD | Min. | Max. |
|---|---|---|---|---|---|
| *Panel A: Funding liquidity variables* | | | | | |
| *Libor* | 0.7133 | 0.6551 | 0.6826 | 0.0650 | 3.0646 |
| *ABCP* | 0.8682 | 0.8325 | 0.7777 | 0.0150 | 3.5355 |
| *Repo* | 0.3985 | 0.3000 | 0.3560 | 0.0100 | 2.0500 |
| *Panel B: Dependent and control variables* | | | | | |
| Full sample | | | | | |
| *SP* | 0.2501 | 0.1123 | 0.4162 | 0.0095 | 5.4560 |
| *Depth* | 75.94 | 216.98 | 167.61 | 0.49 | 1803.20 |
| *OIBDOL* | 49.51 | 1.46 | 1057.47 | −22088.00 | 14975.60 |
| *Ret* | −0.0017 | −0.0009 | 0.0304 | −0.1856 | 0.1875 |
| *LogV* | 13.27 | 12.93 | 3.29 | 5.29 | 20.58 |
| *Ntrade* | 3199.32 | 438.00 | 5343.16 | 2.00 | 23276.00 |
| *VOL* | 0.0181 | 0.0132 | 0.0172 | 0.0000 | 0.1744 |
| Index ETFs | | | | | |
| *SP* | 0.0214 | 0.0227 | 0.0088 | 0.0095 | 0.1003 |
| *Depth* | 364.37 | 270.76 | 332.68 | 24.25 | 1803.20 |
| *OIBDOL* | 291.90 | 140.33 | 2938.42 | −22088.00 | 14975.60 |
| *Ret* | −0.0014 | −0.0003 | 0.0275 | −0.1823 | 0.1459 |
| *LogV* | 18.93 | 18.93 | 0.55 | 16.86 | 20.59 |
| *Ntrade* | 14504.77 | 14069.00 | 4249.85 | 3671.00 | 23276.00 |
| *VOL* | 0.0128 | 0.0097 | 0.0105 | 0.0016 | 0.0717 |
| Full financial ETFs | | | | | |
| *SP* | 0.2829 | 0.1264 | 0.4353 | 0.0267 | 5.4560 |
| *Depth* | 34.67 | 17.40 | 51.79 | 0.49 | 521.67 |
| *OIBDOL* | 14.82 | 1.29 | 184.80 | −5606.20 | 2646.55 |
| *Ret* | −0.0018 | −0.0011 | 0.0308 | −0.1856 | 0.1875 |
| *LogV* | 12.47 | 12.42 | 2.68 | 5.30 | 20.56 |
| *Ntrade* | 1581.50 | 265.50 | 3023.66 | 2.00 | 20789.00 |
| *VOL* | 0.0189 | 0.0140 | 0.0178 | 0.0000 | 0.1744 |
| Financial sector | | | | | |
| *SP* | 0.1155 | 0.0911 | 0.1190 | 0.0267 | 1.6438 |
| *Depth* | 64.30 | 24.37 | 84.34 | 1.08 | 521.67 |
| *OIBDOL* | 28.10 | 6.20 | 310.13 | −5606.20 | 2646.55 |
| *Ret* | −0.0020 | −0.0016 | 0.0315 | −0.1823 | 0.1530 |
| *LogV* | 13.69 | 12.99 | 3.09 | 7.38 | 20.56 |
| *Ntrade* | 3469.22 | 739.50 | 4642.58 | 11.00 | 20789.00 |
| *VOL* | 0.0196 | 0.0149 | 0.0178 | 0.0012 | 0.1483 |

*Notes*: Panel A provides the descriptive statistics for the funding liquidity variables, and Panel B provides the dependent and control variables, with the data covering the period from January 1, 2007 to December 31, 2008. The funding liquidity variables are *Libor*, *ABCP*, and *Repo*. In Panel A, *Libor* is the spread between the 3-month US interbank Libor rate and the overnight index swap on day $t$; *ABCP* is the spread between the 3-month ABCP rates and the overnight index swap on day $t$; and *Repo* is the spread between the mortgage repossession rates minus the government repossession rate on day $t$. In Panel B, *Spread* is the average daily percentage spread for ETF $i$ on day $t$; *Depth* is the daily average of the market depth for ETF $i$ on day $t$; *OIBDOL* is the net buying imbalance variable (buyer-initiated dollars paid less seller-initiated dollars received) for ETF $i$ on day $t$; *Ret* is the daily return for ETF $i$ on day $t$; $V$ is the daily trading volume for ETF $i$ on day $t$; *Ntrade* is the daily number of trades for ETF $i$ on day $t$; and *Vol* is the daily Parkinson volatility for ETF $i$ on day $t$. The full sample represents the descriptive statistics results for 16 ETFs composed of two indices and 14 financial ETFs; the index ETFs represent the descriptive statistics results for SPY and QQQQ index ETFs; the full financial ETFs represent the descriptive statistics results for the 14 financial ETFs; and Financial sector represents the descriptive statistics results for the broad US financial sector group.

sample into subgroups. The index ETFs group is most liquid among all groups, with the smallest average *Spread* of 0.0214 and the highest average *Depth* of 364.37. The second highest liquidity measures (*Spread* and *Depth*) are 0.1155 and 64.30, respectively, for the financial sector group. The most illiquid group is the full financial ETFs group, which indicates that some of financial ETFs, such as global financial ETFs, are less liquid in the market. Consistent with these characteristics, we also find that the index ETFs group has the highest average trading activities. Its *LogV* and *Ntrade* are 18.93 and 14504.77, respectively. Not surprising, the lowest trading activities is from the full financial ETFs group, with a *LogV* and *Ntrade* of 12.47 and 1581.50, respectively. Intuitively, the mean and median returns are both negative, indicating that our sample period covers a down market. Finally, the most volatile group is the financial sector group with average *VOLs* of 0.0196.

Table 2 provides the correlation results. The correlation between *Spread* and *Depth* is significantly negative, which is consistent with Lee et al. (1993). We find a similar significantly negative correlation between *Spread* and *OIBDOL* and a significantly positive correlation between *Depth* and *OIBDOL*. The results

indicate that when buy-initiated trades outnumber sell-initiated trades, the potential exists for an increase in equity liquidity. In addition, the correlation between *OIBDOL* and *Ret* is significantly positive.

Table 2 also shows a significantly positive correlation between *Spread* and *Vol* and a significantly negative correlation between *Depth* and *Vol*. As expected, these results suggest a negative correlation between volatility and equity liquidity (Domowitz et al., 2001). The correlation between *Spread* and the funding liquidity variables (*Libor*, *ABCP*, and *Repo*) are all significantly positive. Furthermore, *Depth* is negatively correlated with all of the funding liquidity variables. These results provide us with a first glance of the positive association between funding liquidity and equity liquidity prior to the regression analysis.

The average levels of the daily funding liquidity variables (*Libor*, *ABCP*, and *Repo*) from January 1, 2007 to December 31, 2008 are illustrated in Fig. 1. The figure clearly shows that these funding liquidity variables often move together, particularly *Libor* and *ABCP*. Fig. 1 also indicates a rise in the funding liquidity variables starting in August 2007. Given that investors experienced

**Table 2**
Correlation matrix.

| Variables | Spread | Depth | OIBDOL | Ret | LogV | Ntrade | Vol | Libor | ABCP |
|---|---|---|---|---|---|---|---|---|---|
| Depth | −0.197*** | | | | | | | | |
| OIBDOL | −0.031*** | 0.049*** | | | | | | | |
| Ret | 0.002 | −0.010 | 0.012* | | | | | | |
| LogV | −0.427*** | −0.491*** | 0.072*** | −0.001 | | | | | |
| Ntrade | −0.286*** | −0.459*** | 0.096*** | 0.006 | 0.837*** | | | | |
| Vol | 0.094*** | −0.177*** | 0.001 | −0.003 | 0.217*** | 0.837*** | | | |
| Libor | 0.216*** | −0.181*** | 0.006 | −0.053*** | 0.177*** | 0.191*** | 0.177*** | | |
| ABCP | 0.206*** | −0.195*** | 0.007 | −0.057*** | 0.192*** | 0.192*** | 0.192*** | 0.978*** | |
| Repo | 0.163*** | −0.164*** | 0.009 | −0.017* | 0.165*** | 0.165*** | 0.165*** | 0.719*** | 0.759*** |

Notes: The table provides the correlation statistics for the empirical variables composed of Spread, Depth, OIBDOL, Ret, LogV, Ntrade, Vol, Libor, ABCP, and Repo. The data cover the period from January 1, 2007 to December 31, 2008. Spread is the average daily percentage spread for ETF $i$ on day $t$; Depth is the daily average of the market depth for ETF $i$ on day $t$; OIBDOL is the net buying imbalance variable (buyer-initiated dollars paid less seller-initiated dollars received) for ETF $i$ on day $t$; Ret is the daily return for ETF $i$ on day $t$; V is the daily trading volume for ETF $i$ on day $t$; Ntrade is the daily number of trades for ETF $i$ on day $t$; Vol is the daily Parkinson volatility for ETF $i$ on day $t$; Libor is the spread between the 3-month US interbank Libor rate and the overnight index swap on day $t$; ABCP is the spread between the 3-month ABCP rates and the overnight index swap on day $t$; and Repo is the spread between the mortgage repossession rates minus the government repossession rate on day $t$. We also use a $t$-test to examine whether the correlation coefficient is significantly different from zero.
* Significance at the 10% level.
*** Significance at the 1% level.
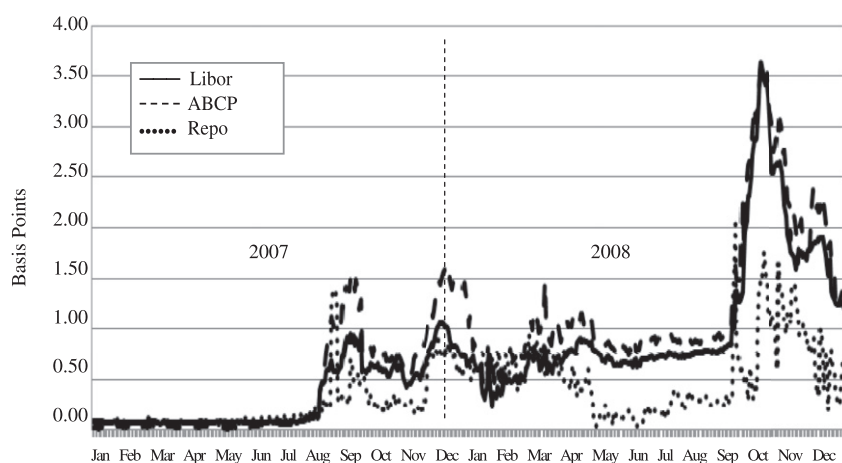


**Fig. 1.** Funding liquidity. Notes: This figure plots the time-series daily values of Libor, ABCP and Repo during the period from January 1, 2007 to December 31, 2008. The Libor is measured by the spread between the US 3-month inter-bank Libor rate and the overnight index swap; the ABCP is measured by the spread between the 3-month ABCP rate and the overnight index swap; and the Repo is calculated as the mortgage repossession rate minus the government repossession rate.

enormous volatility and huge losses in July 2007, this finding is consistent in that funding problems would have been very likely from August 2007 onward.

Many banks experienced additional and even larger losses in November 2007, which is reflected in an increase in the funding liquidity variables. Furthermore, both the Bear Stearns and Lehman Brothers events, which occur in March and September 2008, respectively, have a significant impact on the funding liquidity variables. Overall, our results, which are similar to the results of Brunnermeier (2009) and Melvin and Taylor (2009), show that the funding liquidity variables clearly reflect the funding liquidity situation during the subprime crisis period.

### 3.2. Equity and funding liquidity

#### 3.2.1. Bid–ask spread and funding liquidity

We begin our empirical analysis by providing a deeper understanding of whether funding liquidity affected equity liquidity during the subprime crisis period. Using Eq. (1), we examine the ways in which funding liquidity can affect the bid–ask spread. Table 3

present separate results for the full sample, index ETFs group, full financial ETFs (after deletion of the index ETFs), and the financial sector group.

As Table 3 shows, the coefficients of Vol range from 0.231 to 2.068 with 1% significance level, indicating that an increase in Vol leads to an increase in Spread. In other words, higher market risk may increase the bid–ask spread, which leads to a reduction in market liquidity. Our results are similar to the results of the prior studies (Amihud and Mendelson, 1987; Copeland and Galai, 1983; McInish and Wood, 1992) that find that volatility has a positive impact on the bid–ask spread. Most of our empirical results show that the relation between Ret and Spread is significantly positive for all of our samples, with a discernibly positive and significant autocorrelation between $Spread_{t-1}$ and Spread. Furthermore, the coefficients on LogV are statistically significant from −0.001 to −0.011, suggesting a positive relation between equity liquidity and trading volume.

Our findings, in general, suggest that the short-sales constraint dummy variable, $D_{short}$, has a significantly positive impact on bid–ask spread. This result suggests that because investors could not

**Table 3**
Bid–ask spread and funding liquidity.

| | Full sample | | Index ETFs | | Full financial ETFs | | Financial sector | |
|---|---|---|---|---|---|---|---|---|
| | Coeff. | t-stat. | Coeff. | t-stat. | Coeff. | t-stat. | Coeff. | t-stat. |
| **Panel A: Libor** | | | | | | | | |
| Funding | 0.039 | 5.16*** | 0.001 | 3.27*** | 0.038 | 5.88*** | 0.010 | 2.83*** |
| Ret | 0.236 | 2.90*** | −0.001 | −0.09 | 0.285 | 3.10*** | 0.019 | 1.05 |
| Vol | 1.844 | 8.37*** | 0.231 | 9.87*** | 1.784 | 7.42*** | 0.286 | 4.18*** |
| LogV | −0.010 | −4.44*** | −0.001 | −2.35** | −0.010 | −4.34*** | −0.005 | −7.60*** |
| $SP_{t-1}$ | 0.551 | 60.24*** | 0.448 | 19.18*** | 0.545 | 55.35*** | 0.666 | 29.64*** |
| $D_{short}$ | 0.044 | 2.95*** | −0.001 | −1.55 | 0.052 | 3.08*** | 0.002 | 0.23 |
| C | 0.187 | 4.41*** | 0.023 | 3.25*** | 0.197 | 4.25*** | 0.090 | 8.56*** |
| Adj. $R^2$ | 0.395 | | 0.645 | | 0.397 | | 0.608 | |
| **Panel B: ABCP** | | | | | | | | |
| Funding | 0.022 | 4.85*** | 0.001 | 2.60*** | 0.031 | 5.77*** | 0.007 | 2.55** |
| Ret | 0.244 | 3.00*** | −0.001 | −0.08 | 0.288 | 3.13*** | 0.006 | 0.32 |
| Vol | 1.886 | 8.78*** | 0.244 | 10.81*** | 1.871 | 7.96*** | 0.410 | 6.34*** |
| LogV | −0.010 | −4.72*** | −0.001 | −2.43** | −0.011 | −4.60*** | −0.006 | −10.89*** |
| $SP_{t-1}$ | 0.561 | 61.01*** | 0.454 | 19.56*** | 0.545 | 55.41*** | 0.539 | 30.89*** |
| $D_{short}$ | 0.052 | 3.60*** | −0.001 | −1.58 | 0.062 | 3.78*** | 0.004 | 0.54 |
| C | 0.195 | 4.69*** | 0.023 | 3.32*** | 0.204 | 4.42*** | 0.108 | 12.97*** |
| Adj. $R^2$ | 0.400 | | 0.643 | | 0.397 | | 0.524 | |
| **Panel C: Repo** | | | | | | | | |
| Funding | 0.032 | 3.68*** | 0.001 | 2.36** | 0.031 | 4.20*** | 0.006 | 1.97** |
| Ret | 0.220 | 2.70*** | −0.001 | −0.04 | 0.259 | 2.82*** | −0.009 | −0.63 |
| Vol | 2.068 | 9.76*** | 0.250 | 11.34*** | 2.055 | 8.87*** | 0.391 | 7.24*** |
| LogV | −0.009 | −4.16*** | −0.001 | −2.47** | −0.010 | −3.99*** | −0.004 | −6.97*** |
| $SP_{t-1}$ | 0.555 | 60.95*** | 0.455 | 19.58*** | 0.550 | 56.22*** | 0.629 | 21.56*** |
| $D_{short}$ | 0.072 | 5.26*** | −0.001 | −0.90 | 0.089 | 5.65*** | −0.003 | −0.57 |
| C | 0.180 | 4.26*** | 0.023 | 3.35*** | 0.188 | 4.06*** | 0.078 | 7.75*** |
| Adj. $R^2$ | 0.394 | | 0.643 | | 0.396 | | 0.625 | |

*Notes*: This table provides details of the effects of funding liquidity on the bid–ask spread during the subprime crisis period. The regression model is

$$Spread_{it} = \alpha + \beta_1 Ret_{it} + \beta_2 Vol_{it} + \beta_3 LogV_{it} + \beta_4 Spread_{it-1} + \beta_5 D_{short} + \beta_6 Funding_t + \varepsilon_{it}$$

where the dependent variable is the daily percentage spread for ETF $i$ on day $t$, which is regressed on $Ret$, $LogV$, $Vol$, the short-sales constraint dummy and the funding liquidity variable on day $t$. The *Funding* variable is the *Libor* on trading day $t$ (Panel A), the *ABCP* on trading day $t$ (Panel B), and the *REPO* on trading day $t$ (Panel C). *Ret* is the daily return for ETF $i$ on day $t$; *Vol* is the daily Parkinson volatility for ETF $i$ on day $t$; $V$ is the daily trading volume for ETF $i$ on day $t$; $D_{short}$ is a dummy variable that equals 1 from September 17, 2008 to October 17, 2008, a period when the US Securities and Exchange Commission prohibited short sales of financial company stocks, and zero otherwise; *Libor* is the spread between the 3-month US interbank Libor rate and the overnight index swap on day $t$; *ABCP* is the spread between the 3-month ABCP rates and the overnight index swap on day $t$; and *Repo* is the spread between the mortgage repossession rates minus the government repossession rate on day $t$. The full sample represents the regression results for 16 ETFs comprising of two indices and 14 financial ETFs; the index ETFs represent the regression results for SPY and QQQQ index ETFs; the full financial ETFs represent the regression results for the 14 financial ETFs; and the financial sector represents the regression results for the broad US financial sector group. We use a panel data regression framework and perform the Hausman test on all of our empirical models. We find no misspecification from the use of the random effects model; this model is therefore selected for the estimation of all of our empirical models. The $t$-values examine whether the regression coefficient is significantly different from zero.

** Significance at the 5% level.
*** Significance at the 1% level.

short sell the stocks of financial companies during this period of higher selling pressure, they would have been unwilling to bear such short-term excess risk and would have chosen to buy fewer stocks, thus providing lower liquidity to the market. As a result, the bid–ask spread (equity liquidity) would have increased (decreased).

We now move onto the important discussion of the three funding liquidity variables, *Libor*, *ABCP*, and *Repo*. We find that the coefficients on funding liquidity variables are significantly positive, ranging from 0.001 for the index ETFs to 0.039 for the full sample. These results provide solid evidence that lower funding liquidity increases bid–ask spread and decreases equity liquidity. When investors are faced with huge losses, funding problems occur. The increase in financing the cost of investments leads to a reduction in funding liquidity. When arbitrageurs provide less liquidity and the market becomes increasingly volatile, equity liquidity declines and the bid–ask spread increases.

Most of our results indicate that *Libor* has a much more significant impact than the other two funding liquidity variables on the *Spread* in our study sample. Because systemic events (such as the subprime crisis) can reduce the confidence of investors to provide

funding to the collateral market, investors tend to withdraw their funds from the market and invest in banks due to the perceived safety of such investment. These funding inflows traditionally allow banks to enjoy lower funding costs to meet the demand for loans from the arbitrageurs and intermediaries who have difficulty rolling over their short-term liabilities from the collateral market.[17]

However, banks clearly restricted their lending during the subprime crisis. If not, concerns over interim shocks requiring significant reserve funds would have been high as such movements would have encouraged precautionary hoarding, as would be reflected by an increase in *Libor* (Brunnermeier, 2009). Thus, both intermediaries and arbitrageurs did not have had easy access to sufficient funding to provide liquidity into the market and raise the bid–ask spread. For these reasons, funding illiquidity from the interbank market could well have resulted in a significant increase in the bid–ask spread.

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[17] See Gatev and Strahan (2006).

**Table 4**
Market depth and funding liquidity.

| | Full sample | | Index ETFs | | Full financial ETFs | | Financial sector | |
|---|---|---|---|---|---|---|---|---|
| | Coeff. | t-stat. | Coeff. | t-stat. | Coeff. | t-stat. | Coeff. | t-stat. |
| **Panel A: Libor** | | | | | | | | |
| Funding | −2.05 | −2.20** | −11.38 | −1.65* | −1.07 | −2.95*** | −3.70 | −4.60*** |
| Vol | −32.26 | −0.95 | 421.73 | 0.91 | −50.29 | −3.76*** | −69.25 | −2.45** |
| Ntrade | 0.05 | 0.16 | −0.01 | −5.52*** | −0.01 | −5.03*** | −0.01 | −3.66*** |
| $Depth_{t-1}$ | 0.96 | 293.00*** | 0.91 | 80.27*** | 0.83 | 126.57*** | 0.63 | 31.92*** |
| $D_{short}$ | 1.90 | 0.76 | 21.01 | 1.39 | 1.12 | 1.17 | 5.19 | 2.56** |
| C | 4.75 | 1.17 | 135.94 | 4.14*** | 8.49 | 3.33*** | 12.48 | 3.34*** |
| Adj. $R^2$ | 0.920 | | 0.932 | | 0.738 | | 0.590 | |
| **Panel B: ABCP** | | | | | | | | |
| Funding | −1.96 | −2.58*** | −13.32 | −2.33** | −0.98 | −3.36*** | −3.40 | −5.20*** |
| Vol | −30.38 | −0.92 | 464.90 | 1.06 | −48.97 | −3.70*** | −66.98 | −2.40** |
| Ntrade | 0.11 | 0.38 | −0.01 | −5.47*** | −0.01 | −4.94*** | −0.01 | −3.78*** |
| $Depth_{t-1}$ | 0.96 | 291.36*** | 0.91 | 76.29*** | 0.82 | 126.45*** | 0.63 | 31.46*** |
| $D_{short}$ | 1.64 | 0.69 | 21.85 | 1.51 | 0.92 | 1.00 | 4.58 | 2.36** |
| C | 4.04 | 1.00 | 139.24 | 4.08*** | 8.53 | 3.35*** | 12.93 | 3.41*** |
| Adj. $R^2$ | 0.920 | | 0.932 | | 0.738 | | 0.591 | |
| **Panel C: Repo** | | | | | | | | |
| Funding | −1.64 | −1.83* | −7.04 | −0.72 | −1.06 | −1.93* | −2.58 | −2.17** |
| Vol | −38.23 | −1.36 | 130.61 | 0.31 | −58.81 | −4.56*** | −97.43 | −3.48*** |
| Ntrade | 0.05 | 0.09 | −0.01 | −5.37*** | −0.01 | −5.20*** | −0.01 | −4.41*** |
| $Depth_{t-1}$ | 0.91 | 295.53*** | 0.92 | 85.02*** | 0.83 | 127.84*** | 0.65 | 33.47*** |
| $D_{short}$ | −0.23 | −0.05 | 11.00 | 0.80 | 0.06 | 0.07 | 1.42 | 0.77 |
| C | 9.71 | 1.20 | 130.21 | 4.05*** | 8.33 | 3.28*** | 11.41 | 3.21*** |
| Adj. $R^2$ | 0.920 | | 0.931 | | 0.738 | | 0.585 | |

*Notes*: This table provides details of the effects of funding liquidity on market depth during the subprime crisis period. The regression model is

$$Depth_{it} = \alpha + \beta_1 Vol_{it} + \beta_2 Ntrade_{it} + \beta_3 Depth_{it-1} + \beta_4 D_{short} + \beta_5 Funding_t + \varepsilon_{it}$$

where the dependent variable is the daily market depth for ETF $i$ on day $t$, which is regressed on Vol, Ntrade, the short-sales constraint dummy and the funding liquidity variable on day $t$. The *Funding* variable is the *Libor* on trading day $t$ (Panel A), the *ABCP* on trading day $t$ (Panel B), and the *Repo* on trading day $t$ (Panel C). *Vol* is the daily Parkinson volatility for ETF $i$ on day $t$; *Ntrade* is the daily number of trades for ETF $i$ on day $t$; $D_{short}$ is a dummy variable that equals 1 from September 17, 2008 to October 17, 2008, a period when the US Securities and Exchange Commission prohibited short sales of financial company stocks, and zero otherwise; *Libor* is the spread between the 3-month US interbank Libor rate and the overnight index swap on day $t$; *ABCP* is the spread between the 3-month ABCP rates and the overnight index swap on day $t$; and *Repo* is the spread between the mortgage repossession rates minus the government repossession rate on day $t$. The full sample represents the regression results for 16 ETFs comprising of two indices and 14 financial ETFs; the index ETFs represents the regression results for SPY and QQQQ index ETFs; the full financial ETFs represents the regression results for the 14 financial ETFs; and the financial sector represents the regression results for the broad US financial sector group. We use a panel data regression framework and perform the Hausman test on all of our empirical models. We find no misspecification from the use of the random effects model; this model is therefore selected for the estimation of all of our empirical models. The $t$-values examine whether the regression coefficient is significantly different from zero.
* Significance at the 10% level.
** Significance at the 5% level.
*** Significance at the 1% level.

### 3.2.2. Market depth and funding liquidity

In this section we examine the relation between market depth and funding liquidity. Because Lee et al. (1993) argue that any discussion of liquidity must include both spread and depth,[18] we examine the ways in which funding liquidity affects market depth. The results in Table 4 show that an increase in Vol has a clearly negative impact on Depth, as the coefficients are negative except for the index ETFs. The market risk is obviously high during such periods of high volatility. Limit order traders can choose to reduce liquidity further, either by shifting depth away from the quotes or by reducing the depth provided at a given price, we therefore find a negative relation between market depth and volatility.[19] In addition, we find a significantly positive relation between Depth and $Depth_{t-1}$. These results indicate higher autocorrelation for the market depth variable.

Furthermore, our results reveal a significantly negative relation between Ntrade and Depth. The theoretical models suggest different results on the relation between trading volume and depth. On the one hand, because transactions consume market liquidity, depth and volume are negatively related (Lee et al., 1993). On

the other hand, when orders have a higher probability of execution, investors may place more limit orders; an increase in trading volume would, therefore, raise both limit orders and market depth (Chung et al., 1999).[20]

Finally, Table 4 shows that the coefficients of Funding range from −0.98 to −13.32. Such results imply that any increase in the funding liquidity variables leads to a reduction in Depth. Given that the subprime crisis led to a fall in housing prices in early 2007, investors suffered huge losses on their portfolios and tended to liquidate their portfolios in the market. These actions caused a rise in the financing costs of investors and a likely reduction in funding liquidity. To liquidate their portfolios, investors may have elected to increase their market orders and reduce their limit orders, with limit order traders potentially choosing to reduce their provision of equity liquidity and market depth.

As we observe from Tables 3 and 4, most of our results show that Libor has a more significant impact on equity liquidity relative to the collateral market funding liquidity variables. In addition, we find that the financial ETFs yield more significant results than

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[18] Lee et al. (1993) find that volume shocks widen the spread and reduce depth.
[19] Our results provide support for the opinion of Goldstein and Kavajecz (2004).

[20] Our results, which are similar to those reported by Ahn et al. (2001), provide general support for Lee et al.'s (1993) argument.

**Table 5**
Net buying imbalance and funding liquidity.

| | Full sample | | Index ETFs | | Full financial ETFs | | Financial sector | |
|---|---|---|---|---|---|---|---|---|
| | Coeff. | t-stat. | Coeff. | t-stat. | Coeff. | t-stat. | Coeff. | t-stat. |
| **Panel A: Libor** | | | | | | | | |
| Funding | −52.08 | −1.97** | −366.94 | −1.81* | −12.98 | −2.28** | −4.24 | −2.46** |
| Ret | 423.63 | 1.09 | 918.90 | 0.27 | 331.11 | 4.05*** | 53.75 | 2.29** |
| $Ret_{t-1}$ | 811.85 | 2.03** | 14601.12 | 2.96*** | 95.41 | 1.16 | 9.07 | 0.38 |
| LogV | 13.97 | 9.58*** | 30.81 | 2.16** | 67.30 | 5.01*** | 289.65 | 6.30*** |
| Vol | 150.01 | 0.87 | −1328.35 | -0.11 | 555.33 | 1.39 | 189.55 | 1.52 |
| $OIBDOL_{t-1}$ | 0.02 | 1.92* | 0.03 | 1.07 | 0.06 | 4.44*** | 0.13 | 4.24*** |
| $D_{short}$ | 108.13 | 1.56 | 715.45 | 1.32 | −3.79 | −0.25 | −3.43 | −0.79 |
| C | 99.40 | 1.12 | −76.58 | −0.39 | 10.59 | 0.4 | 12.99 | 1.70* |
| Adj. $R^2$ | 0.014 | | 0.020 | | 0.023 | | 0.100 | |
| **Panel B: ABCP** | | | | | | | | |
| Funding | −44.94 | −1.82* | −236.77 | −1.36 | −2.95 | −0.61 | −2.52 | −1.69* |
| Ret | 393.14 | 1.01 | 907.62 | 0.27 | 339.64 | 4.14*** | 62.91 | 2.65*** |
| $Ret_{t-1}$ | −181.84 | −0.47 | 14458.38 | 2.93*** | 102.97 | 1.25 | 6.08 | 0.25 |
| LogV | 18.72 | 8.28*** | 29.24 | 2.16** | 64.34 | 7.15*** | 3.40 | 5.08*** |
| Vol | 113.65 | 0.66 | 341.11 | 0.16 | 675.30 | 1.72* | 48.41 | 0.08 |
| $OIBDOL_{t-1}$ | 0.02 | 2.06** | 0.03 | 1.08 | 0.06 | 4.53*** | 0.14 | 4.62*** |
| $D_{short}$ | 110.25 | 1.52 | 811.15 | 1.54 | −15.47 | −1.08 | −1.54 | −0.35 |
| C | 65.70 | 0.74 | −255.69 | −0.21 | 6.30 | 1.36 | −31.34 | −3.93*** |
| Adj. $R^2$ | 0.012 | | 0.020 | | 0.017 | | 0.077 | |
| **Panel C: Repo** | | | | | | | | |
| Funding | −14.22 | −0.36 | −180.81 | −0.57 | −5.66 | −0.77 | −7.91 | −2.09** |
| Ret | 446.04 | 1.15 | 705.38 | 0.21 | 320.73 | 4.51*** | 56.50 | 2.41** |
| $Ret_{t-1}$ | 777.86 | 1.94* | 13292.83 | 2.72*** | 95.89 | 1.34 | 9.81 | 0.41 |
| LogV | 20.57 | 10.40*** | 27.11 | 2.11** | 64.73 | 7.67*** | 277.17 | 6.09*** |
| Vol | 32.44 | 0.04 | −3199.79 | −0.30 | 103.78 | 0.63 | 110.98 | 1.01 |
| $OIBDOL_{t-1}$ | 0.02 | 1.79* | 0.03 | 1.07 | 0.06 | 4.80*** | 0.13 | 4.31*** |
| $D_{short}$ | 66.21 | 1.04 | 703.57 | 1.43 | −15.88 | −1.34 | −4.26 | −1.66* |
| C | 14.74 | 0.77 | 7.91 | 0.05 | 4.33 | 1.09 | 9.08 | 1.26 |
| Adj. $R^2$ | 0.015 | | 0.019 | | 0.017 | | 0.093 | |

*Notes*: This table provides details of the effects of funding liquidity on net buying imbalance during the subprime crisis period. The regression model is

$$OIBDOL_{it} = \alpha + \beta_1 Ret_{it} + \beta_2 Ret_{it-1} + \beta_3 LogV_{it} + \beta_4 Vol_{it} + \beta_5 OIBDOL_{it-1} + \beta_6 D_{short} + \beta_7 Funding_t + \varepsilon_{it}$$

where the dependent variable is the daily net buying imbalance for ETF $i$ on day $t$, which is regressed on the return, lag-one period return, LogV, Vol, the short-sales constraint dummy and the funding liquidity variable on day $t$. The Funding variable is the Libor on trading day $t$ (Panel A), the ABCP on trading day $t$ (Panel B), and the Repo on trading day $t$ (Panel C). Ret is the daily return for ETF $i$ on day $t$; $V$ is the daily trading volume for ETF $i$ on day $t$; Vol is the daily Parkinson volatility for ETF $i$ on day $t$; $D_{short}$ is a dummy variable that equals 1 from September 17, 2008 to October 17, 2008, a period when the US Securities and Exchange Commission prohibited short sales of financial company stocks, and zero otherwise; Libor is the spread between the 3-month US interbank Libor rate and the overnight index swap on day $t$; ABCP is the spread between the 3-month ABCP rates and the overnight index swap on day $t$; and Repo is the spread between the mortgage repossession rates minus the government repossession rate on day $t$. The full sample presents the regression results for 16 ETFs comprising of two indices and 14 financial ETFs; the index ETFs represent the regression results for SPY and QQQQ index ETFs; the full financial ETFs represent the regression results for the 14 financial ETFs; and the financial sector represent the regression results for the broad US financial sector group. We use a panel data regression framework and perform the Hausman test on all of our empirical models. We find no misspecification from the use of the random effects model; this model is therefore selected for the estimation of all of our empirical models. The $t$-values examine whether the regression coefficient is significantly different from zero.
* Significance at the 10% level.
** Significance at the 5% level.
*** Significance at the 1% level.

index ETFs, because the subprime crisis had a more direct impact on the financial industry than other industries. Finally, we find that funding illiquidity can lead to an increase in the bid–ask spread and a decrease in market depth, which indicates that lower funding liquidity causes a reduction in equity liquidity. In sum, our results provide support for our hypothesis that the funding constraints of liquidity suppliers really do matter.

### 3.3. Net buying imbalance and funding liquidity

We now examine whether funding liquidity affects the trading behavior of investors by investigating the relation between the net buying imbalance and the funding liquidity variables (Libor, ABCP, and Repo) based on Eq. (3). As shown in Table 5, Vol is positively related to OIBDOL. In addition, the coefficients of both $Ret_t$ and $Ret_{t-1}$ are positive. An increase in LogV leads to an increase in the net buying imbalance; the coefficients are significant, ranging from 3.40 to 289.65. These results indicate that investors tend to place buy orders in the market when the daily return, daily lag return,

volatility, and trading volume of ETFs are higher. We also find a positive autocorrelation between OIBDOL and $OIBDOL_{t-1}$.

Our results, in general, reveal negative relations between OIBDOL and the funding liquidity variables. The coefficients of Libor are all negatively significant, ranging from −4.24 to −366.94. Such results are more significant for the interbank market and for the cases of the full financial ETFs (after deleting the index ETFs) and financial sector groups. For the two groups regarding financial ETFs, four out of six cases are negatively significant for the funding liquidity measures. However, the results from net buying imbalance are weaker than those from bid–ask spread and market depth.

These results indicate that, faced with illiquid funding, liquidity providers such as the financial intermediaries and arbitrageurs may encounter funding constraints due to redemption pressure from investors and losses on their holding positions. As a result, they may have insufficient funding to provide liquidity into the market and thus become liquidity demanders. Liquidity providers and investors may therefore elect to participate in the market by placing more sell orders or buying fewer stocks, ultimately leading to a reduction in the net buying imbalance. These shifts could

**Table 6**
Elasticity of the regression model for financial industries.

| | Libor | | | | ABCP | | | | Repo | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coeff. | t-stat. | Elasticity | Adj. $R^2$ | Coeff. | t-stat. | Elasticity | Adj. $R^2$ | Coeff. | t-stat. | Elasticity | Adj. $R^2$ |
| *Panel A: Spread* | | | | | | | | | | | | |
| Banking | 0.018 | 4.06*** | 0.079 | 0.434 | 0.015 | 3.38*** | 0.085 | 0.368 | 0.014 | 2.32** | 0.036 | 0.400 |
| Broker | 0.076 | 14.47*** | 0.382 | 0.431 | 0.057 | 13.12*** | 0.349 | 0.415 | 0.058 | 6.42** | 0.162 | 0.314 |
| Insurance | 0.078 | 4.04*** | 0.166 | 0.665 | 0.061 | 3.90*** | 0.156 | 0.665 | 0.056 | 1.98** | 0.066 | 0.661 |
| Global | 0.198 | 5.35*** | 0.146 | 0.368 | 0.139 | 4.63*** | 0.126 | 0.364 | 0.206 | 3.62** | 0.085 | 0.360 |
| *Panel B: Depth* | | | | | | | | | | | | |
| Banking | −1.87 | −4.60*** | −0.061 | 0.757 | −1.66 | −5.00*** | −0.066 | 0.757 | −1.55 | −2.58*** | −0.028 | 0.754 |
| Broker | −2.31 | −3.71*** | −0.058 | 0.849 | −1.61 | −3.28*** | −0.050 | 0.848 | −1.22 | −2.26** | −0.022 | 0.827 |
| Insurance | −1.50 | −2.20** | −0.038 | 0.780 | −1.05 | −1.96** | −0.032 | 0.780 | −2.00 | −1.98** | −0.030 | 0.788 |
| Global | −1.65 | −4.50*** | −0.106 | 0.747 | −1.51 | −4.97*** | −0.118 | 0.748 | −1.38 | −2.52** | −0.050 | 0.743 |
| *Panel C: OIBDOL* | | | | | | | | | | | | |
| Banking | −57.48 | −2.43** | −2.639 | 0.052 | −13.85 | −2.15** | −0.704 | 0.070 | −15.18 | −1.27 | −0.354 | 0.077 |
| Broker | −12.11 | −2.12** | −0.776 | 0.022 | −2.29 | −0.53 | −0.179 | 0.020 | −1.27 | −0.80 | −0.098 | 0.045 |
| Insurance | −4.55 | −1.98** | −0.903 | 0.156 | −3.44 | −1.79* | −0.831 | 0.155 | −2.54 | −1.69* | −0.187 | 0.206 |
| Global | −0.81 | −0.28 | −0.086 | 0.050 | −0.41 | −0.40 | −0.053 | 0.076 | −0.57 | −0.73 | −0.034 | 0.066 |

*Notes*: This table provides the elasticity of funding liquidity variables (Libor, ABCP and Repo) for the regression model. The regression model is

$$Depth_{it} = \alpha + \beta_1 Vol_{it} + \beta_2 Ntrade_{it} + \beta_3 Depth_{it-1} + \beta_4 D_{short} + \beta_5 Funding_t + \varepsilon_{it} \quad Spread_{it}$$
$$= \alpha + \beta_1 Ret_{it} + \beta_2 Vol_{it} + \beta_3 LogV_{it} + \beta_4 Spread_{it-1} + \beta_5 D_{short} + \beta_6 Funding_t + \varepsilon_{it} \quad OIBDOL_{it}$$
$$= \alpha + \beta_1 Ret_{it} + \beta_2 Ret_{it-1} + \beta_3 LogV_{it} + \beta_4 Vol_{it} + \beta_5 OIBDOL_{it-1} + \beta_6 D_{short} + \beta_7 Funding_t + \varepsilon_{it}$$

where the elasticity is measured as each regression coefficient multiplied (divided) by the average of the independent (dependent) variable. The dependent variable in Panel A is the daily percentage spread for ETF $i$ on day $t$, which is regressed on $Ret$, $LogV$, $Vol$, short-sales constraint dummy, and funding liquidity variable on day $t$. The dependent variable in Panel B is the daily market depth for ETF $i$ on day $t$, which is regressed on the $Vol$, $Ntrade$, short-sales constraint dummy, and funding liquidity variable on day $t$. The dependent variable in Panel C is the daily net buying imbalance for ETF $i$ on day $t$, which is regressed on the return, $Vol$, $LogV$, short-sales constraint dummy, and funding liquidity variable on day $t$. We use a panel data regression framework and perform the Hausman test on all of our empirical models. We find no misspecification from the use of the random effects model; this model is therefore selected for the estimation of all of our empirical models.
* Significance at the 10% level.
** Significance at the 5% level.
*** Significance at the 1% level.

cause equity illiquidity as well as further price declines. The results thus provide support for our hypothesis that lower funding liquidity ultimately leads to a reduction in the net buying imbalance.

### 3.4. The effects on the financial industry

In this section, we examine how funding liquidity affects equity liquidity and the net buying imbalance for financial ETFs in various financial industries, using Eqs. (1)–(3) to calculate elasticity, which is measured as each regression coefficient multiplied by the average of the independent variable and divided by the average of the dependent variable. This method enables us to compare the liquidity and the net buying imbalance for each type of financial ETF and determine which are more responsive to changes in funding liquidity.

As Panel A of Table 6 shows, a significantly positive relation is discernible between the funding liquidity variables and the bid–ask spread, particularly for the brokerage group. Specifically, the elasticity of brokerage group ranges from 0.162 to 0.382 and is the highest among all groups. These results indicate that funding illiquidity leads to higher funding costs and insufficient capital to provide the requisite liquidity to the market, thus increasing the bid–ask spread for the banking, brokerage, insurance, and global groups. Increases in *Libor*, *ABCP*, and *Repo* funding liquidity variables in Panel B also lead to a reduction in *Depth* for the banking, insurance, brokerage, and global groups, with the elasticity coefficient ranging from −0.022 to −0.118. We find that the global group is the most sensitive group, as the elasticity is the highest in absolute value among all the groups, and these results could be due to that the means of both trading volume and dollar depth for the global group are lowest among all the groups.

Finally, we show that an increase in the *Libor*, *ABCP*, and *Repo* all have a significantly negative impact on the net buying imbalance

for the insurance groups, with the coefficient ranging from −2.54 to −4.55. The finding may be because their everyday operations and services are likely to result in a greater need for funding than the other financial industries. Furthermore, we also find that the *Libor* coefficients are −57.48 for the banking group and −12.11 for brokerage groups, and both are statistically significant. Therefore, an increase in the *Libor* variable also leads to a reduction in the net buying imbalance not only for the insurance group but also for the banking and brokerage groups.

When intermediaries and arbitrageurs begin finding it difficult to roll over their short-term liabilities from the collateral market, they look for banks to obtain their necessary funding. However, with an increase in illiquidity in the interbank funding market, intermediaries and arbitrageurs will find the normal channel for obtaining funding at lower cost essentially closed to them. As a result, they will elect to sell off more risky financial industry ETFs to profit from their position. *Libor* is, therefore, has a more significant impact on *OIBDOL* than the other funding liquidity variables.

### 4. Conclusions

We explore the relation between funding liquidity and equity liquidity using three different funding liquidity variables to proxy for interbank and collateral market liquidity. Our study uses intraday data to measure equity liquidity on the two index ETFs and 14 financial ETFs (which are divided into five groups). We investigate the ways in which funding liquidity may have affected equity liquidity during the subprime crisis period.

With an increase in funding illiquidity during the subprime crisis period, we observe a corresponding increase in the bid–ask spread and a decrease in market depth, indicating a general reduction in equity liquidity. Using net buying imbalance to measure the

trading behavior of investors, we also find that, with a reduction in funding liquidity, investors chose to participate in the market by placing more sell orders or fewer buy orders, leading to an overall reduction in the net buying imbalance. However, such findings are weaker than those from bid–ask spread and market depth.

These results provide support for our hypothesis that a significant liquidity shock or continuous bad news can trigger enormous redemption pressure for retail investors, resulting in funding problems for the financial intermediaries. Such a situation leads to severe funding illiquidity and may induce intermediaries to become short-term liquidity demanders, rushing to sell the more liquid assets from their existing portfolios. This response provides even lower equity liquidity and further deterioration in liquidity.

Our results show that *Libor*, in general, has more significant impacts than the collateral market funding liquidity variables on both equity liquidity and net buying imbalance; we also find that financial ETFs are more significant than index ETFs, as financial industry felt the impact of the subprime crisis more than other industries. A comparison of the financial ETF subgroups shows that the bid–ask spread are more responsive to changes in funding liquidity for the brokerage group, which may be due to a higher demand for funding of their operations and services than among other financial industries. In sum, our study provides a better overall understanding of the effect of the liquidity–supplier funding constraint during the subprime crisis period.

## Appendix A. Details of the exchange-traded fund data

| Ticker | Full title of ETFs | Exchange | Observations | Definition |
|---|---|---|---|---|
| *1. Index ETFs* | | | | |
| SPY | SPDR S&P 500 | NYSEArca | 504 | The index exchange-traded funds which track the S&P 500 Index |
| QQQQ | PowerShares QQQ | NasdaqGM | 504 | The index exchange-traded funds which track the Nasdaq 100 Index |
| *2. Broad US financial sector* | | | | |
| XLF | Financial Select Sector SPDR | Amex | 504 | The underlying index includes commercial and investment banking and capital markets, diversified financial services, insurance and real estate |
| IYF | iShares Dow Jones US Financial Sector | NYSEArca | 504 | The underlying index includes companies in the banking, non-life insurance, life insurance, real estate and general finance industry groups |
| VFH | Vanguard Financials ETF | Amex | 504 | Designed to track the performance of the MSCI US Investable Market Financials index |
| IYG | iShares Dow Jones US Financial Services | NYSEArca | 504 | A subset of the Dow Jones US Financial index |
| *3. Banking* | | | | |
| KBE | KBW Bank ETF | Amex | 504 | The underlying index includes national money center banks and regional banking institutions listed on the US stock markets |
| KRE | KBW Regional Banking ETF | Amex | 504 | An equal weighted index of geographically diverse companies representing regional banking institutions listed on the US stock markets |
| RKH | Regional Bank HOLDRs | Amex | 504 | Designed to diversify clients' investment in the regional banking industry through a single, exchange-listed instrument representing undivided beneficial ownership of the underlying securities |
| IAT | iShares Dow Jones US Regional Banks | NYSEArca | 504 | The underlying index is a subset of the Dow Jones US bank index small and mid-size banks |
| *4. Brokerage and asset management* | | | | |
| IAI | iShares Dow Jones US Broker-Dealers | NYSEArca | 504 | Companies providing a range of specialized financial services, such as securities brokers and dealers, online brokers and securities or commodities exchanges |
| KCE | KBW Capital Markets ETF | Amex | 504 | Situated in the US capital market industry and includes broker dealers, asset managers, trust and custody banks and a stock exchange |
| *5. Insurance* | | | | |
| KIE | KBW Insurance ETF | Amex | 504 | Situated in the insurance and publicly traded in the US, including personal and commercial lines, property/casualty, life insurance, reinsurance, brokerage and financial guarantees |
| IAK | iShares Dow Jones US Insurance | NYSEArca | 502 | The underlying index includes companies in the following Full line insurance, insurance brokers, property and casualty insurance reinsurance and life insurance industry groups |
| *6. Global* | | | | |
| IXG | iShares S&P Global Financials | NYSEArca | 504 | A subset of the S&P Global 1200 Index |
| DRF | Wisdom Tree International Financial | NYSEArca | 503 | Measures the performance of dividend-paying companies in developed markets within the 'International Financial' sector outside of the US and Canada |

## Acknowledgement

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