WHEN SHORT SELLERS AGREE TO DISAGREE: SHORT SALES, VOLATILITY, AND HETEROGENEOUS BELIEFS

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ABSTRACT

MATTHEW RINGGENBERG: When Short Sellers Agree to Disagree: Short Sales, Volatility, and Heterogeneous Beliefs.
(Under the direction of Adam Reed)

Using a novel database that contains information on the quantity of shares demanded and supplied in the equity lending market, I test a previously unexplored implication that follows from models of heterogeneous beliefs: the idea that short sales lead to increased volatility because they alter the supply of shares in the market. Because short sales and returns are endogenously determined, I use an instrumental variables framework to identify their relation. Specifically, I use shifts in the lendable supply of shares to identify the impact that short sales have on both the level and volatility of returns and I find evidence that short sales lead to higher contemporaneous volatility. Moreover, I find that this effect is strongest when demand curves are more likely to be downward sloping as a result of heterogeneous beliefs, a finding consistent with the predictions of heterogeneous belief models. In other words, I find that when there is disagreement among investors, the trades of short sellers lead to increased volatility.

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1. Introduction

Following the short sales ban that occurred during the financial crisis of 2008 there is an increased desire to understand the impact that short sales have on the formation of asset prices.[1] While there is a well-established literature examining the relation between short sales and returns, relatively little is known about the relation between short sales and volatility. In this paper, I present new empirical evidence on the relation between short sales, returns, and volatility by isolating the impact of supply shocks that result from short sales. Because short sales involve borrowing a share from an existing investor and selling it to a new investor, the opening of a short position effectively leads to an increase in the supply of shares. While early asset pricing models assume perfectly elastic demand curves, a number of studies have suggested that asset supply can impact returns.[2] However, few studies have examined the supply shocks that result from short sales. As a result, several important questions remain unanswered: Do the supply shocks that result from short sales impact returns? If so, do these supply shocks lead to increased volatility as short positions are opened and closed?

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[1]Comerton-Forde, Jones, and Putninš (2010) examine market conditions around short sales and find that short sellers can be important providers of liquidity. Boehmer, Jones, and Zhang (2009) examine the impact of the 2008 short sales ban and find evidence that banned stocks had worse liquidity than a matched sample of non-banned stocks.

[2]For example, Shleifer (1986) examines stocks that have been added to the S&P 500 index and finds evidence of downward sloping market demand curves. Because index funds are likely to purchase stocks that have been added to the S&P 500 index, the announcement of the index inclusion leads to an outward shift in the demand curve. Shleifer documents significant positive abnormal returns following these demand shocks, a finding consistent with downward sloping market demand curves. Bagwell (1992) analyzes individual shareholder bids in 32 Dutch auction share repurchases and finds that shareholder valuations are heterogeneous; she concludes that the assumption of perfectly elastic demand curves is unlikely to be a valid approximation of actual demand schedules.

Using an instrumental variables framework in tandem with a unique database that contains the quantity of shares demanded and supplied in the equity lending market, I isolate the impact of supply shocks that result from short sales. Specifically, I use shifts in the lendable supply of shares to identify the effect that short sales have on the level and volatility of returns; the results suggest that short sales lead to increased volatility. In addition, I find evidence that this relation is a consequence of downward sloping market demand curves as predicted by models of heterogeneous investor beliefs including Miller (1977) and Mayshar (1983). Overall, the results suggest that heterogeneous investor beliefs do have an influence on asset prices and that short sales do exhibit a causal impact on the volatility of returns. In other words, I find that when short sellers agree to disagree with other investors, their trades lead to increased volatility.

Academic studies have found evidence of a number of mechanisms that link short sales and returns.[3] Several papers have found evidence suggesting that short sellers are able to identify stocks that are more likely to experience negative returns (e.g., Boehmer, Jones, and Zhang (2008), (2010); Engelberg, Reed, and Ringgenberg (2010)). Moreover, a number of papers have found that information about the quantity of short selling reveals private information that in turn causes other investors to reconsider their own valuation (e.g., Senchack and Starks (1993); Aitken, Frino, McCorry, and Swan (1998)). Even so, many investors and market commentators believe that short sellers are able to drive down prices and even cause market crashes, an idea that implies short sellers can cause prices to depart

[3]A large literature has examined the relation between short sales and returns using returns as the dependent variable in a regression on short volume or short interest. However, because short sales and returns are both endogenous to the market, these regressions are unable to test for a causal relation. This study is the first attempt that I am aware of to specifically test for a relation between short sales and returns that is independent of investor preferences and the latent flow of information.

from their fundamental values.[4] While a number of studies have found that short sales improve price discovery and market quality, the supply shocks examined in this study represent one possible explanation for the belief that short sales can cause prices to depart from fundamentals.

Knowledge about the mechanisms that relate short sales, investor beliefs, and returns is crucial to understanding how asset prices are determined in equilibrium. Standard asset pricing models often require non-trivial assumptions about the belief set possessed by investors and the ability of investors to short an asset. For instance, the standard capital asset pricing model (Sharpe (1964), Lintner (1965)) assumes that all investors have homogeneous expectations about the risk and return of every security. Similarly, contingent claim based asset pricing models (e.g., Rubinstein (1976), Breeden and Litzenberger (1978)) often assume that investors agree on the probability distribution of aggregate consumption levels. However, a number of theoretical models have argued that heterogeneous investor beliefs do impact asset prices. In particular, Miller (1977), Mayshar (1983), Varian (1985), and Hong and Stein (2003), among others, have all argued that heterogeneous investor beliefs play an important role in the formation of asset prices.

In both the Miller (1977) and the Mayshar (1983) models, investor participation in the market for each stock is endogenous and it is assumed that investors possess differing opinions about each stock's return. When short selling is restricted or costly, only the most optimistic investors will choose to participate in the market and so each stock will tend to be held by the investors with the highest valuations. As a result, in Miller's model the market demand curve for each stock will be downward sloping and the equilibrium price will be

[4]For example, in September of 2008 the SEC said, "At present, it appears that unbridled short selling is contributing to the recent, sudden price declines in the securities of financial institutions unrelated to true price valuation."

determined by the marginal valuation.[5] An interesting implication of these models is that, given a downward sloping demand curve, a change in the supply of shares will lead to a change in the marginal valuation which, in turn, results in a contemporaneous price change that is independent of the information environment. Thus, heterogeneous opinion models provide a theoretical basis for the commonly held belief that short sales can cause stock returns to change.[6]

In this paper, I present a direct empirical test of this theorized relation between short sales and returns. One complication to any test of this theory, however, is the fact that short sales are unlikely to occur for reasons that are exogenous from either the level or the volatility of returns. For example, short sellers are likely to initiate a short position when they believe a stock is overvalued and future returns are likely to be negative.[7] Thus, in order to test for a causal relation between short sales and returns, I turn to a two-stage instrumental variables framework. Specifically, I use the quantity of shares available to be borrowed (i.e., the loan supply) as an instrument to identify the impact of short sales. D'Avolio (2002) provides motivation for the use of loan supply as an instrument; he notes that equity lending desks are often run separately from portfolio allocation desks, and as a result, the short-term loan supply is likely exogenous from returns. In order to measure loan supply and the quantity of shares sold short, I use a proprietary dataset from Data Explorers, a leading provider of data in the equity lending market. The data is sourced from a wide variety of

[5]Mayshar's model is more complicated because the equilibrium price depends on both the level of expectations and the diversity of opinion and he explicitly considers the relation between asset prices and both the average and the marginal investor, while Miller focuses only on the marginal investor. However, Mayshar shows that under certain conditions, his model leads to the same conclusions as the Miller model.

[6]While the impact of short sales on the supply of shares is not directly modeled in the heterogeneous beliefs literature, Miller (1977) acknowledges that, "...short selling increases the effective supply."

[7]Anecdotal evidence suggests that a significant amount of short volume also occurs due to hedging demands that are not necessarily related to returns.

market participants including hedge funds, prime brokers, and investment banks and the data contains information on the quantity of shares demanded and supplied in the equity lending market at the daily frequency.

Using loan supply as an instrument, I find that a one standard deviation increase in the quantity of shares on loan is associated with a negative 10.94 basis point change in daily returns. The results suggest that short sales change the effective supply of shares and, as a result, they change the level of returns. Heterogeneous belief models, including Miller (1977), suggest that market demand curves are downward sloping as a result of divergence in investor opinions. As these opinions become more diverse, the market demand curve will become steeper. Accordingly, the impact of supply shocks caused by short selling should be stronger when investor beliefs are more disperse. Using dispersion in analyst estimates as a proxy for divergence in investor opinions, I find that the relation between short sales and returns is strongest when market demand curves are more steeply downward sloping. For firms in the highest quintile of divergence in opinions, I find that a one standard deviation increase in the quantity of shares on loan is associated with a negative 27.58 basis point change in daily returns.

The evidence suggests that the opening of a short position results in a positive supply shock that impacts returns; however, the closing of a short position results in an identically sized negative supply shock. Thus, as short positions are opened and closed, the supply curve will shift in and out and the net effect of a short transaction may lead to increased volatility. Using an instrumental variables framework in combination with the Heterogeneous Autoregressive Realized Volatility (HAR-RV) class of volatility models as in Corsi (2009) and Andersen, Bollerslev, and Diebold (2007), I find evidence that short sales lead to increased contemporaneous volatility. Specifically, a one standard deviation increase in short sales is associated with an increase in daily log realized volatility of 1.83%. Moreover, as predicted by models of heterogeneous beliefs, this relation is strongest when divergence of opinion is highest.

Overall, the findings of this paper contribute to three different strands of the existing literature. First, the paper adds to the empirical evidence on the shape of the demand curve for stocks and finds evidence that market demand curves do in fact slope downward. Second, the paper confirms existing results that find a relation between heterogeneous investor beliefs and equity returns and moreover, it provides novel empirical evidence on *how* heterogeneous expectations influence returns and influence the shape of the market demand curve. Finally, the paper provides new empirical evidence on the relation between short sales and both the level and volatility of equity returns.

The rest of the paper proceeds as follows: Section 2 provides an overview of the existing literature. Section 3 describes the theoretical mechanisms that relate short sales, heterogeneous beliefs, and returns and provides an overview of the methodology used to test these theories. Section 4 describes the data and discusses the calculation of key variables. Section 5 presents the analyses and findings. Section 6 concludes.

2. The Relation between Short Sales, Investor Beliefs, and Equity Returns

This paper sits at the intersection of two different but often related strands of the extant literature. First, this paper contributes to the growing body of research investigating the role that short sales play in financial markets. Second, this paper is related to theoretical models on the role played by heterogeneous investor beliefs in the formation of asset prices. In this section, I provide an overview of the existing literature in each of these areas and I outline the theoretical relation between short sales, heterogeneous investor beliefs, and the level and volatility of equity returns.

2.1 Short Sales and the Level of Returns

There is a large literature examining the relation between short sales and the level of equity returns. In one of the first studies to formally examine the relation between short sales and equity returns, Seneca (1967) outlines two competing theories on the impact of short sales and finds that short interest is negatively related to future prices. Subsequently, a number of papers have confirmed the negative relation between short sales and future returns. Asquith, Pathak, and Ritter (2005) use institutional ownership as a proxy for short sale constraints and find that the negative relation between short interest and future returns is strongest when firms are more likely to experience short sale constraints. Cohen, Diether, and Malloy (2007) isolate shifts in the supply and demand for shorting using data from a large institutional investor and they find that increases in shorting demand are associated with negative future returns. In fact, a number of existing papers find evidence consistent with the common belief that short sales lead to lower returns. However, to date, little work has been done to explore the idea that short sales impact returns specifically because they alter the supply of shares in the market. Thus, even though a number of papers have found evidence of a negative relation between short sales and returns, it is unclear if short sellers are causing lower returns or if they are merely better able to identify which firms are likely to experience lower returns.

Given the documented relation between short sales and negative future returns, a number of papers have theorized that short sellers are better informed than the general population of investors. Several papers have found evidence suggesting that short sellers are better able to predict which stocks will experience negative returns. Boehmer, Jones, and Zhang (2008) examine NYSE order data from 2000 – 2004 and find that short sellers are able to identify which stocks will experience lower returns over the next twenty days. Moreover, they find that non-program institutional trades earn especially low returns, a result consistent with the idea that short sellers trade on superior information. Similarly, Engelberg, Reed, and Ringgenberg (2010) examine short volume around publicly released news articles and find that the negative relation between short sales and future returns is more than twice as strong in the presence of news. Moreover, they find that this result is concentrated in client trades, not market-maker trades, a finding which lends further support to the idea that short sellers possess superior information.

In a related literature, a number of papers have found that the release of data on the quantity of short selling is also associated with lower returns. Senchack and Starks (1993) examine returns for stocks that had short interest levels published in the Wall Street Journal during the period 1980-1986 and they find the release of short interest data is associated with a small drop in returns. Aitken, et al. (1998) use intraday data on the Australian stock exchange to test the information content of short positions and they find that stocks immediately experience negative abnormal returns following the publication of short transactions. They conclude that short positions reveal negative information. Interestingly, the Aitken, et al. finding is consistent with more than one possible mechanism relating short sales and returns. While Aitken, et al. interpret it as evidence that short sales reveal negative information, it is also consistent with the story that short sales impact returns because market demand curves are downward sloping and short sales alter the supply of shares outstanding. However, because information on short positions is instantly revealed in Australia, they are unable to isolate the impact of information from their analysis.

2.2 Short Sales and the Volatility of Returns

While a number of studies examine short sales and returns, relatively little has been done to explore the link between short sales and volatility. In one of the few papers to investigate the topic, Henry and McKenzie (2006) examine 21 firms listed on the Hong Kong Stock Exchange and they find evidence that firms experience higher volatility following a period of short selling. Angel, Christophe, and Ferri (2003) find that short selling has a positive and monotonic relation with volatility, although they note that additional research regarding the possible lead/lag relation between short sales and volatility is still needed. In other words, their results do not explain the nature of the relation between short sales and volatility and it is unclear if: 1) short selling leads to volatility, 2) volatility leads to short selling, or 3) both short selling and volatility are driven by some other factor.

More recently, Diether, Lee, and Werner (2009) investigate the trading strategies used by short sellers and they theorize that short sellers may act as opportunistic risk bearers on days with high volatility. They proxy for volatility using the intraday (*high* – *low*)/*high* and they find evidence that short sales are positively correlated with contemporaneous volatility, however they view this as evidence that short sellers are opportunistic risk bearers, not that short sales lead to increased volatility.

Finally, Kaplan, Moskowitz, and Sensoy (2009) work with a money manager to exogenously shift the supply of lendable shares for certain stocks and they find mixed evidence on the relation between short sales and volatility. While they find no difference in volatility between stocks available for lending versus stocks not available for lending in their experiment, they do find some evidence that stocks with high short interest are associated with increased volatility. Nevertheless, their study focuses primarily on the impact of a change to the supply of lendable shares and not on the impact of short selling itself.

2.3 Heterogeneous Beliefs

Early asset pricing models typically assumed that all investors possessed homogeneous expectations. For instance, the now ubiquitous capital asset pricing model (Sharpe (1964, Lintner (1965)) assumes that investors possess identical estimates of the expected risk and return for every asset.[8] More recently, however, economists have begun to examine both the validity of this assumption and the implications that result from relaxing it.

[8]Mayshar (1983) provides several quotations from both Sharpe and Lintner explaining their belief that the assumption of homogeneous expectations is without loss of generality. From Sharpe (1970, p. 113), "…a model based on disagreement has little value in a positive role." From Lintner (1969, p. 371), "Any carryover of…Ricardian notations of 'marginal' buyers setting prices in purely competitive markets is utterly unjustified and misleading when dealing with security markets under uncertainty. Every investor is a marginal holder with respect to his last share…of each security he holds."

In a widely cited article, Miller (1977) presents a verbal model that argues that heterogeneous investor beliefs will influence equilibrium asset prices when short selling is restricted in the marketplace. In a related article, Mayshar (1983) elaborates on the ideas presented in Miller (1977) and argues that early asset pricing models overlooked the importance of heterogeneous beliefs because they did not recognize that investor participation in the market for each stock is endogenous. When short selling is restricted or costly, only the most optimistic investors will choose to participate in the market and so each stock will tend to be held by the investors with the highest valuations. As a consequence, the models argue that the market demand curve for each stock will be downward sloping and the equilibrium price will be a function of the marginal valuation. While Miller focuses only on the marginal valuation, Mayshar attempts to bridge the division in the literature by showing that equilibrium prices are determined by both the average and the marginal investors.

Following Miller (1977), a number of models have expanded the literature on heterogeneous beliefs and short sale constraints. Jarrow (1980) builds upon Miller's model and notes that it is important to consider dispersion in expectations regarding the covariance of future asset prices, not just the mean expectations. Varian (1985) analyzes the impact of divergence of opinion in an Arrow-Debreu contingent claims model and finds that higher dispersion in beliefs will likely be associated with reduced prices. Xu (2007) develops a model that predicts increased skewness in the presence of short sale constraints when investors possess differing beliefs. Finally, Harrison and Kreps (1978) use heterogeneous expectations to show that short sale constraints can lead to prices that are above the valuations of even the most optimistic investors. The Harrison and Kreps model can be viewed as an explanation of speculative bubbles under the assumption that investors possess bounded rationality.

The heterogeneous beliefs literature commonly assumes bounded rationality and at least some limit to arbitrage, often in the form of short sales constraints. Many of the models allow the existence of heterogeneous expectations by assuming bounded rationality in the sense that investors view their own signal as more informative than the signal they receive from prices. Davis, Pagano, and Schwartz (2007) provide a number of examples regarding the validity of the assumption of heterogeneous beliefs in financial markets. For example, they note that analyst recommendations about a particular stock often disagree and the fact that most stocks have both long and short volume is suggestive of disagreement. Assuming that at least some long and short investors trade for reasons other than hedging or liquidity, then the mere fact that long and short investors agree to disagree is evidence of heterogeneous expectations.

Moreover, the assumption of limits to arbitrage due to short sale constraints seems likely to represent a reasonable depiction of true market conditions. Fabozzi (2004, pg 235) provides an overview of the many constraints to short selling that exist including: the cost of borrowing shares, the difficulty locating and establishing an equity loan position, the risk that a short position will not be maintained due to recall risk, margin requirements, the fact that short sellers do not receive the proceeds of the sale, and legal and institutional restrictions on short selling.[9]

[9]For example, many mutual funds are precluded from participating in short transactions. Almazan, Brown, Carlson, and Chapman (2004) find that 73% and 66% of mutual funds were restricted from engaging in short sales in 1994 and 2000, respectively. Moreover, of those allowed to short, only 10% actually did use short transactions.

To date, the empirical asset pricing literature has largely utilized heterogeneous belief models to explain specific stylized facts. For example, Gervais, Kaniel, and Mingelgrin (2001) find that volume is a significant predictor of future returns and they theorize that this might be due to the increased visibility that results from trading volume which in turn leads to a change in the demand and price as postulated in Miller (1977). Similarly, Diether, Malloy, and Scherbina (2002) find that higher dispersion in analyst forecasts is associated with lower future returns, a result also predicted by Miller (1977). In this paper, I provide a novel direct test of heterogeneous belief models. While the tests and findings in this paper are consistent with a broad class of heterogeneous belief models, in what follows I will specifically focus on implications from the Miller and Mayshar models.

3. Theory and Methodology

In both the Miller (1977) and the Mayshar (1983) models, investor participation in the market for each stock is endogenous and it is assumed that investors possess differing opinions about each stock's expected return. When short selling is restricted or costly, only the most optimistic investors will choose to participate in the market and so each stock will tend to be held by the investors with the highest valuations. As a result, the market demand curve for each stock will be downward sloping and the equilibrium price will be determined by the marginal valuation.[10]

An interesting implication of these models is that given a downward sloping demand curve, a change in the quantity of shares outstanding will lead to a change in the marginal valuation which in turn results in a price change that is independent of the information environment. Thus, heterogeneous opinion models provide a theoretical basis for the commonly held belief that short sales lead to return changes. When a short sale is initiated, the short seller borrows a share from an existing long investor and then sells this borrowed share to another investor. Even though the original investor has loaned out her share, she retains the principal characteristics of her original long position, including the right to receive

[10]In these models, individual demand curves are not downward sloping. However, the market demand curve can be calculated as the horizontal sum of all individual demand curves and because market participation is endogenously determined and investors possess different beliefs, the resulting market demand curve will be downward sloping.

all cash flow distributions.[11] Moreover, the investor who buys the share from the short seller also receives the characteristics of a long position. In a sense, one share has become two shares and thus the opening (closing) of a short position can be viewed as a positive (negative) supply shock.[12] If market demand curves are in fact downward sloping due to heterogeneous investor beliefs then the supply shock that results from a short sale will cause returns to change.

Accordingly, I propose and test a previously unexplored implication that follows from the Miller and Mayshar models: the idea that short sales lead to increased volatility because they change the effective supply of shares outstanding. The Miller (1977) model suggests that an increase (decrease) in the number of shares outstanding will be associated with a decrease (increase) in contemporaneous returns. Because the opening and closing of a short position leads to an increase and decrease in the supply of shares outstanding, respectively, it follows that short sales will lead to return changes. Unfortunately, one of the most widely used measures of short transactions, short volume, only provides information about the opening of short positions. Thus, short volume data cannot be used to examine the round-trip impact of a short transaction in order to test for a relation with volatility. While the other widely used measure of short transactions, short interest, does provide information about the closing of positions, it is typically available at only the monthly or semi-monthly frequency. These data limitations might help explain why there has been relatively little work investigating the relation between short sales and the volatility of returns.

[11]The original owner of the share retains the right to participate in any corporate actions that occur while the share is on loan, including tender offers and dividend distributions. However, although the original owner of the share does not retain voting rights while the share is on loan, she is generally allowed to recall the share at any time and for any reason, including recalling shares in order to participate in votes. For a detailed discussion, see Fabozzi (2004).

[12]While the impact of short sales on the supply of shares is not directly modeled in the heterogeneous beliefs literature, Miller (1977) acknowledges that, "...short selling increases the effective supply."

In this paper, I use daily firm-level data on the quantity of shares demanded and supplied in the equity loan market in order to examine the relation between short sales and returns. By using equity loan quantities, I can measure the opening and closing of short transactions at a daily frequency.

4. Data

4.1 Equity Loan Data

The equity loan database used in this study comes from Data Explorers, a leading provider of data in the equity loan market. In the normal course of its business, Data Explorers aggregates and distributes information regarding equity loan positions at the daily frequency. The data is sourced directly from a wide variety of contributing customers including beneficial owners, hedge funds, investment banks, lending agents, and prime brokers.

The database contains a number of statistics summarizing transactions in the equity loan market at the stock-day level. Specifically, the database used in this study includes the following information: the date, a stock identifier, the quantity of shares loaned out (*LoanQty*), the quantity of shares available to be borrowed (*LoanSupply*), the utilization rate, and the cost of borrowing a share. The utilization rate is the quantity of shares loaned out as a percentage of shares available to be borrowed and the cost of borrowing a share is measured in deciles.

To construct the sample, Data Explorers selected the 1,500 largest U.S. stocks in their database over the period January 1, 2007 through December 31, 2009 and the resulting sample contains 1,157,016 daily observations. Panel A of Table 1 provides summary statistics for the equity loan database. The mean (median) loan quantity as a percentage of shares outstanding is 6.51% (4.33%) and the mean (median) loan supply as a percentage of shares outstanding is 26.13% (26.77%). For the typical firm, the utilization rate is approximately 22% (15%) and the cost of borrowing a share falls in the lowest price decile. Interestingly, these statistics suggests that for most firms the market contains an excess supply of shares available to be borrowed even though the cost of borrowing a share is relatively low.

Combined, the market participants that contribute to this database account for a substantial portion of all equity loans in the marketplace. Panel B of Table 1 examines the correlation between the equity loan quantity in the database and two common measures of short sales, short volume and short interest. The mean (median) correlation between equity loan quantity and semi-monthly short interest from Compustat is 0.70 (0.78), a finding which suggests that the equity loan quantity in this database does represent a significant portion of total equity loan volume. Interestingly, the correlation between equity loan quantity and short volume is significantly lower at 0.11 (0.10). However, one of the important features of loan quantity in this database is that it makes it possible to ascertain not just when a short position is initiated, but also when it is closed. In contrast, short volume represents only newly initiated short transactions.

In this study I use equity loan quantities as a measure of short selling. Accordingly, it is important to consider the potential impact of security settlement procedures. Typically, equity transactions in the U.S. are settled within three business days of the trade, often referred to as T+3. Thus, when a short seller initiates a position, she must borrow and deliver the shares by T+3. Because a short seller must pay a fee each day to borrow a security, the short seller is likely to borrow the share on or as close to T+3 as possible (Geczy, Musto, and Reed (2002)). Thus, to match equity loan transactions to the occurrence of an underlying short sale, I shift equity loan transactions back by three days. To make it clear that loan quantity is a measure of short selling that occurred on day T, throughout the paper I will consistently refer to equity loan quantity that has been shifted back by three days as $LoanQty_t$.

4.2 Data Compilation

I combine the equity loan database with data from Compustat, CRSP, and TAQ. From Compustat, I add the log of the book to market ratio as of the end of the previous quarter. From CRSP, I add daily returns, price, volume, and shares outstanding. I also add the daily value weighted market return and the daily bid-ask spread as a fraction of the closing mid-price. I calculate *Size* as the log of the mean market capitalization for each firm over the previous quarter.

I calculate daily realized volatility using the sum of squared five minute returns as in Andersen, Bollerslev, Diebold, and Ebens (2001). Specifically, for each firm *i* on day *t*, I calculate the following:

$$RV_{i,t} = \sqrt{\sum_{m=1}^{78} r_{t,m}^2} \qquad (1)$$

where $r_{t,m}$ represents the five minute continuously compounded return from TAQ calculated over the 78 five-minute intervals that occur during regular trading hours. I exclude all cancelled and invalid trades in TAQ. In the analyses that follow, I use the natural logarithm of the realized volatility measure constructed above.

5. Analyses and Results

As previously discussed, there are a number of possible mechanisms that link short sales and returns. As argued by Clark (1973) in his well-known mixture of distributions hypothesis, trading volume and returns are necessarily related due to their common dependence on latent information. However, in this study I aim to isolate the impact that short selling has on returns due to the supply shocks that result from equity loans. Thus, in order to test for this relation while controlling for latent information, I employ an instrumental variables (IV) regression framework. I use data on the equity lending market in tandem with the instrumental variables framework in order to examine both the level and volatility of returns.

5.1 Motivation for Potential Instruments

The IV analysis answers the question: but for the actions of short sellers, what would the level and volatility of equity returns look like? The first step in any IV analysis is to find a suitable set of instrumental variables. To be a valid instrument, a variable needs to possess the following properties: (1) it must be correlated with the endogenous regressor, and (2) it must not itself belong in the explanatory model of interest. Here, these properties require that the instruments are correlated with short sales (as measured by loan quantity) and at the same time, the instruments are not a necessary component of any model the purports to explain the level or the volatility of returns.

The extant literature provides motivation for a potential instrument that satisfies these conditions. D'Avolio (2002) notes that, "short-run [equity loan] supply is essentially vertical. This is due to a separation of authority at many fund complexes between portfolio allocation and lending and by the lack of high frequency transparency in loan rates…" In other words, because loan desks are often run separately from allocation desks, it is likely that short-term equity loan supply is largely exogenous from the factors that determine returns. As a consequence, the evidence suggests that the supply of shares available to be borrowed (hereafter, "loan supply") may satisfy the exclusion restriction discussed above.

Moreover, there are a number of reasons that loan supply may change for reasons that are largely exogenous from returns. For example, while the original owner of a share retains all cash flow rights while a share is on loan, the owner must recall the share in order to participate in corporate votes. Thus, loan supply may contract around corporate votes in a manner that is exogenous from returns (e.g., Christoffersen, Geczy, Musto, and Reed (2007), Aggarwal, Saffi, and Sturgess (2010)).[13] Similarly, Thornock (2010) finds that loan supply significantly contracts around ex-dividend dates as a consequence of dividend taxation policies. Consistent with this finding, Figure 2 examines the equity lending market in the 20 days before and after ex-dividend dates and finds evidence of a significant supply shift. Panel A of Figure 2 examines standardized loan supply, where standardized loan supply is loan supply as a percentage of shares outstanding standardized to have a mean of zero and unit variance, and finds that abnormal loan supply drops from a high of over 2% before the

[13]In a survey conducted by the International Corporate Governance Network (Lintstock (2004)), large institutional investors were asked if they ever recalled shares solely for voting purposes. Of the 31 survey participants who had lent shares, 4 respondents had a policy of always recalling shares around votes, 2 more respondents often recalled shares around votes, depending on the importance of the issues to be decided, and 2 respondents had a policy against recalling lent shares merely to vote them. 21 of the respondents recalled shares around votes in special circumstances.

ex-dividend date to a low of less than -2% on the ex-dividend date. Moreover, Panel B documents a sharp increase in the loan fee around this same time period. The results suggest that ex-dividend dates lead to a significant shift in loan supply that is likely to be exogenous from the factors that determine returns.

While the evidence suggests that loan supply is likely to satisfy the exclusion restriction, for loan supply to be considered a potential instrument it must also be correlated with the quantity borrowed by short sellers (hereafter, "loan quantity"). D'Avolio (2002) notes that supply shifts, in particular loan recalls, can often prevent short sellers from maintaining their short positions: "Having been recalled, the mean (median) time before the short can be reestablished with the lender is 23 (nine) trading days… The resulting sluggishness explains numerous accounts by professional short sellers of not being able to reestablish recalled loans 'at any price.'" Similarly, Kolasinski et al. (2010) provide additional evidence on the relation between loan supply and loan quantity in a study that examines equity lending across multiple lenders. They find evidence that the loan market is highly fragmented and that search costs make it difficult for short sellers to establish positions with different lenders. As a result, changes to the supply of shares at one lender, even if they represent a small change relative to the market supply of shares, may significantly influence the ability of investors to maintain or establish a short sale in the near term. Combined, the evidence discussed above suggests that not only is loan supply likely to be largely exogenous from the factors that determine returns, it is also likely to be correlated with the quantity borrowed by short sellers. Accordingly, I consider loan supply as a potential instrument.[14]

As shown by Kolasinski et al. (2010), the opaque and fragmented structure of the equity lending market may make it difficult for short sellers to establish positions with different lenders. When loan supply is relatively low, small changes to it may have a considerable impact on the loan quantity borrowed. On the other hand, when loan supply is relatively high, the loan quantity borrowed may be less sensitive to changes in supply. Due to this potential non-linearity, I also consider the square of loan supply as an instrument.

In the instrumental variables analyses that follow in sections 5.2 and 5.3, I provide formal tests on the validity of these instruments. However, as a motivational experiment, I first investigate the relation between loan supply and public news events. There is a growing literature that finds that public news events are related to equity returns and volume (e.g., Antweiler and Frank (2006), Tetlock (2008), Engelberg et al. (2010), etc.). Accordingly, by examining the relation between loan supply and news, it is possible to see if loan supply is exogenous from at least one significant determinant of equity returns.

Table 2 presents the results of four different panel data regressions of the form:

$$y_{i,t} = \alpha + \beta_1 News_{i,t} + \beta_2 LoanQty_{i.t} + \beta_3 Bid\text{-}Ask_{i,t} + \beta_4 B/M_{i,q-1} + \beta_5 Size_{i,q-1} + \beta_6 MarketRet_{t-1} + \beta_7 Ret_{i,t-1} + \beta_8 Ret_{i,t-2} + FE + \varepsilon_{i,t} \quad (2)$$

where the dependent variable $y_{i,t}$ is: (1) $LoanSupply_{i,t}$, (2) $LoanSupply_{i,t}^2$, (3) $Returns_{i,t}$, or (4) $Volume_{i,t}$. $News_{i,t}$ measures the number of negative words in a news article as a fraction of total words according to the negative word list developed by Loughran and McDonald (2011)

[14]Saffi and Sigurdsson (2010) also use loan supply as an instrumental variable in an analysis that examines how stock price efficiency is affected by short sale constraints. While they find that short sale constraints impact the efficiency of stock prices at the weekly and monthly frequency, their results are consistent with the idea that loan supply is largely exogenous from contemporaneous returns.

and data on news articles is from the Dow Jones News Archive as in Engelberg et al. (2010). Each regression investigates the impact of public news events on the variable of interest and I include firm fixed effects with robust standard errors clustered by firm in order to control for unobserved heterogeneity and correct for heteroskedasticity and within-firm correlation.

In order to be a suitable instrument, loan supply should be related to equity returns only through the endogenous regressor, loan quantity. Accordingly, I include loan quantity in models 1 and 2 in order to examine the relation between public news and loan supply after including the impact of loan quantity. For consistency, I also include loan quantity in models 3 and 4. In addition, I include firm size (*Size*), book to market (*B/M*), lagged firm returns ($Ret_{i,t-1}$, $Ret_{i,t-2}$), and the lagged value weighted market return ($MarketRet_{t-1}$) in order to control for well-documented relations between these variables and equity returns. *Size* is calculated as the log of the mean market capitalization for each firm over the previous quarter from CRSP and *B/M* is calculated as the log of the book to market ratio for each firm as of the end of the previous quarter from Compustat. Finally, in order to control for the impact of liquidity, I include the bid-ask spread (*Bid-Ask*) from CRSP, calculated daily as a fraction of the closing mid-price.

The extant literature suggests that news events will be related to returns and volume, however, if loan supply is exogenous from the factors that determine returns then loan supply should not be influenced by public news events. The negative and statistically significant coefficient on *News* in model 3 suggests that news articles with a high percentage of negative words are negatively related to returns. In other words, negative news is strongly associated with negative contemporaneous returns at the daily frequency, a finding consistent with the existing literature. Similarly, the significant coefficient of 6.7934 on *News* in model 4 implies that a one unit increase in negative news events is associated with a 6.8% increase in volume as a percentage of shares outstanding. Importantly, as theorized above, both loan supply and loan supply squared appear to be largely unaffected by public news events. While loan supply does exhibit a relation with past market and firm returns, the fact that it is not related to contemporaneous news events that are known to impact contemporaneous returns and volume is evidence that it may satisfy the exclusion restriction. Accordingly, I use *LoanSupply* and $LoanSupply^2$ as instruments to identify the relation between returns and supply shocks that result from equity loans.

In the instrumental variable results discussed below, I provide additional tests that examine if loan supply is adequately correlated with loan demand and validly excluded from the model of interest.

5.2 Level of Returns

I begin by examining the relation between short sales and the level of returns. As previously discussed, the Miller (1977) model implies that heterogeneous beliefs will lead to a downward sloping market demand curve. This leads to an interesting implication, namely, that an exogenous change in the supply of shares will lead to a change in marginal valuation which in turn results in a price change. Thus, heterogeneous belief models provide a theoretical basis for the commonly held belief that short sales cause returns to change. In this section, I seek to investigate this theory using an instrumental variables analysis and I find evidence that short sales do impact the level of returns in a manner that is independent from the latent information flow.

To investigate the theorized relation between short sales and returns, I estimate the following system of equations:

$$LoanQty_{i,t} = \beta_1 LoanSupply_{i,t} + \beta_2 LoanSupply^2_{i,t} + \beta_3 Bid\text{-}Ask_{i,t} + \beta_4 B/M_{i,q-1} + \beta_5 Size_{i,q-1} + \beta_6 MarketRet_{t-1} + \beta_7 Ret_{i,t-1} + \beta_8 Ret_{i,t-2} + FE + \varepsilon_{i,t} \quad (3)$$

$$Ret_{i,t} = \beta_1 \widehat{LoanQty}_{i,t} + \beta_2 Bid\text{-}Ask_{i,t} + \beta_3 B/M_{i,q-1} + \beta_4 Size_{i,q-1} + \beta_5 MarketRet_{t-1} + \beta_6 Ret_{i,t-1} + \beta_7 Ret_{i,t-2} + FE + \varepsilon_{i,t} \quad (4)$$

where *LoanSupply* and $LoanSupply^2$ are the excluded instruments and $\widehat{LoanQty}$ is the fitted value of *LoanQty* from equation (3). The system uses shocks to loan supply to identify the impact that short sales (as measured by daily loan quantity) have on contemporaneous returns.

In order to ensure that my results are not impacted by a weak instrument problem, I present the results of the first stage regression in addition to the second stage results. Specifically, Table 3 presents the results from equation (3) and Table 4 presents the results from equation (4). I begin by estimating a parsimonious model that examines the impact of loan quantity on returns without including additional control variables. Models 1 and 2 present the results without and with fixed effects, respectively. In both models, the fitted value of *LoanQty* in Table 4 is negatively related to contemporaneous returns and the results are significant at the 1% level. Consequently, the results suggest that an increase (decrease) in the quantity of short sales leads to a decrease (increase) in returns that same day.

Because there are a number of variables that have been shown to impact short sales and returns, I next add several control variables to the specification. I add the daily bid-ask spread as a fraction of the closing mid-price (*Bid-Ask*) in order to control for liquidity effects documented by Diether, Lee, and Werner (2009) and I add two lags of daily returns (*Ret*) to control for the response of short sellers to previous returns as shown in Diether, Lee, and

Werner (2009). To control for the well-documented relation between returns and the book-to-market ratio, firm size, and the market return, I also add these three variables to the specification. Specifically, I add the log of the book to market ratio for each firm as of the end of the previous quarter from Compustat (*B/M*), the log of the mean market capitalization for each firm over the previous quarter from CRSP (*Size*), and the value-weighted market return from CRSP (*MarketRet*). In order to avoid adding an additional endogenous regressor to the system of equations, I use the market return as of the previous trading day. Finally, I add a firm fixed effect to models 2 and 4 in order to control for possible unobserved heterogeneity at the firm level and in all models I use robust standard errors clustered by firm and date.

After including these control variables I find that the negative contemporaneous relation between short sales and returns remains intact. Models 3 and 4 present the results without and with fixed effects, respectively. The negative and statistically significant coefficient estimate on *LoanQty* in model 4 of Table 4 suggests that a one standard deviation increase (decrease) in the quantity of shares sold short is associated with a negative (positive) 10.94 basis point change in daily returns.[15] Because the IV framework allows for inference that is independent of the latent information process, I interpret this result causally. In other words, ceteris paribus, an increase in short sales causes a negative change in returns. Thus, the results shed new light on the commonly held belief that short sellers are able to change returns.

Of course, in order to make a valid inference from an IV framework, it necessary that the instruments satisfy both the weak instrument and the exclusion properties. The first stage results shown in Table 3 demonstrate that *LoanSupply* does in fact have a statistically

[15] 10.94 bps = -0.0163 * 6.76%. Annualized, this amounts to 27.56% = -0.0163 * 6.76% * 252.

significant relation with *LoanQty*. In all models, the F-statistic strongly rejects the null hypothesis that the excluded instruments are weak. In addition, for each model in Table 4 I examine whether or not the excluded instruments are suitably independent of the error process in order to ensure that they satisfy the exclusion restriction. In all cases, the Sargan–Hansen test of overidentifying restrictions fails to reject the null that the instruments are valid. Accordingly, I conclude that the instruments satisfy the necessary conditions and the inferences discussed above are valid.

The results not only confirm that short sales impact contemporaneous returns, but they also provide novel evidence on the mechanism that leads to this relation. While a number of studies have shown evidence of a negative correlation between short sales and returns, the existing literature has yet to disentangle the impact of information from the relation. While it is likely that multiple mechanisms play a role in the relation between short sales and returns, here, the results provide evidence of a relatively unexplored mechanism that follows from the Miller (1977) model. Specifically, the results suggest that one of the ways that short sales impact returns is by increasing the effective supply of shares outstanding.

As previously discussed, the Miller (1977) model assumes that investor participation in the market for each stock is endogenous and investors possess differing opinions about each stock's return. As a result, in Miller's model the market demand curve for each stock is downward sloping. Given a downward sloping demand curve, changes to the supply of shares will impact returns. The results in Table 4 provide novel evidence that supply shocks resulting from short sales do in fact impact returns. However, if short sales impact returns as a result of supply shocks in combination with downward sloping demand curves, then firms with more steeply downward sloping demand curves should be more sensitive to short sales. This observation provides the motivation for my next test.

There are a number of models that generate downward sloping market demand curves. For example, the well known Grossman and Stiglitz (1980) model posits that following a supply shock, uniformed investors may incorrectly interpret price changes as coming from adjustments to the information set of informed investors. As a consequence, supply increases will lead to price drops. By contrast, in the Miller (1977) model market demand curves are downward sloping as a result of divergence in investor opinions. As these opinions become more (less) diverse, the market demand curve will become steeper (shallower). Thus, all else equal, firms with investors that have more diverse beliefs should be more sensitive to the supply shock that results from short sales.

In order to test if the results in Table 4 are indeed a result of downward sloping demand curves as predicted in the Miller (1977) model, I calculate analyst dispersion as in Diether, Malloy, and Scherbina (2002) and I group firms into quintiles based on analyst dispersion. I then re-estimate the system shown in equations (3) and (4) using analyst dispersion as a proxy for divergence in investor beliefs. To investigation whether firms with higher divergence in investor beliefs are more sensitive to short sales, I estimate the system separately for each of the analyst dispersion quintiles. If the predictions of the Miller model hold, then the impact of supply shocks should be most pronounced for firms in quintile 5, when divergence in investor beliefs is highest and market demand curves are steepest.

The results, presented in Table 5, provide strong evidence that short sales impact returns as a result of downward sloping market demand curves as posited by Miller (1977). For firms with the highest analyst dispersion, the negative relation between short sales and returns is nearly three times larger. In quintile five, a one standard deviation increase (decrease) in the quantity of shares on loans is associated with a negative (positive) 27.58 basis point change in daily returns and the result is significant at the 1% level.[16] Moreover, the result is also strong for firms in the second highest quintile of analyst dispersion where a one standard deviation increase (decrease) in the quantity of shares on loans is associated with a negative (positive) 17.64 basis point change in daily returns.[17] By contrast, quintiles 1 through 3 display no significant relation between short sales and returns. In fact, not only are the coefficients not statistically significant at even the 10% level, but they are an order of magnitude smaller than those presented in quintiles 4 and 5.

As before, in order to make a valid inference from an IV framework, it necessary that the instruments satisfy both the weak instrument and the exclusion properties. The first stage results, available upon request, confirm that *LoanSupply* does in fact have a statistically significant relation with *LoanQty*. Moreover, for every specification in Table 5 the Sargan–Hansen test fails to reject the null that the instruments are valid. Accordingly, I conclude that the instruments satisfy the necessary conditions and the inferences discussed above are valid.

These results are consistent with the theory that short sales impact returns as a result of supply shocks. In addition, the results provide novel empirical evidence that heterogeneous expectations influence returns and influence the shape of the market demand curve. However, it is important to note that the theory and results presented herein suggest a symmetric relation between short sales and returns. In other words, if demand curves are downward sloping, an increase in the supply of shares should be associated with lower returns and a decrease in the supply of shares should be associated with higher returns. Thus,

[16] 27.58 bps = -0.0411 * 6.76%. Annualized, this amounts to 69.50% = -0.0411 * 6.76% * 252.

[17] 17.64 bps = -0.0261 * 6.76%. Annualized, this amounts to 44.46% = -0.0261 * 6.76% * 252.

while the results provide evidence that short sales impact returns in a manner that is unrelated to latent information they also suggest that, ceteris paribus, the round trip impact of a short sale should be zero.

As noted by Seneca (1967) in an early empirical paper examining the link between short sales and returns, “Some traders see a favorable reaction [to high short interest], claiming that increases in short sales represent a boost to potential demand because eventually these positions must be covered…Others see a bearish effect and view high short interest conditions as a signal of pessimism and a judgment that a down-turn is likely.” Thus, the results in this study provide empirical evidence that reconciles two long standing conflicting beliefs about the impact of short sales. While the opening of a short sale is associated with lower contemporaneous returns, the closing of a short position is associated with higher contemporaneous returns.

Interestingly, this fact also suggests that short sales will impact the volatility of returns. As short positions open and close, the results suggest that they shift the supply curve back and forth, causing returns to change. Thus, ceteris paribus, higher amounts of short selling should be associated with higher volatility.

5.3 Volatility of Returns

There is relatively little known about the relation between short sales and the volatility of returns. As a result, I employ several different analyses in order to examine both the general relation and the impact that occurs after controlling for latent information flow. I begin by conducting a simple sorting exercise that examines the relation between short sales and daily realized volatility. As before, I measure short sales using daily loan quantity as a percentage of shares outstanding and each day I group firms into deciles using this measure. I then calculate the mean and median daily realized volatility for each decile, where realized volatility is the sum of squared five minute returns from TAQ as shown in equation (1) in Section 4.2. The results, shown in Figure 1, provide evidence of a positive and monotonic relation between short sales and volatility. For firms in the highest decile of short sales, the mean (median) realized volatility is 30% (37%) higher than for firms in the lowest decile.

In order to examine if this relation is statistically significant, I next turn to the conventional GARCH framework introduced by Bollerslev (1986). I augment the standard GARCH(1,1) model with an additional term, $|\Delta LoanQty_t|$, that measures changes in loan quantity. Because volatility measures absolute changes in returns, I calculate the absolute value of changes in loan quantity as well. In other words, since the opening of a short position is associated with lower returns and the closing of a position is associated with higher returns, I expect both increases and decreases in loan quantity to be associated with higher volatility. Accordingly, I estimate the following time-series regression for each firm:

$$ret_t = m + \sqrt{h_t}\varepsilon_t \tag{5}$$

$$h_t = \omega + \alpha(r_{t-1} - m)^2 + \beta h_{t-1} + \gamma|\Delta LoanQty_t| \tag{6}$$

where ret_t is the daily return for each firm from CRSP.

Table 6 presents the results. Model 1 displays the estimates for a traditional GARCH(1,1) model while model 2 displays the results for the augmented model including loan quantity as an additional regressor in the volatility equation. The positive and statistically significant coefficient on loan quantity in model 2 suggests that short sales are associated with higher contemporaneous volatility at the daily frequency. Moreover, the coefficient estimate for the conditional error variance, β, is more than 3% lower in model 2, a result which suggests that loan quantity has picked up some of the predictive power of the conditional variance. Thus, the results confirm the link between short sales and contemporaneous volatility shown in Figure 1.

Although the GARCH results strongly suggest that short sales are associated with higher volatility, they do not explain the source of this relation. It is unclear, a priori, if short selling occurs for reasons that are exogenous from volatility; in fact, short selling may occur as a result of it. For instance, while short sales can be used for speculative purposes, they are often utilized for hedging reasons. Figlewski and Webb (1993) find that short sales increase following the introduction of traded options and Danielsen and Sorescu (2001) argue that this effect stems from market makers tendency to hedge their option exposures using short sales. Thus, it is possible that short sales and volatility are associated as a result of option trading and not because of the relation theorized in the Miller (1977) model. Moreover, a number of papers have shown evidence that short sellers benefit from an asymmetric information advantage (e.g., Boehmer, Jones, and Zhang (2008), (2010); Engelberg, Reed, and Ringgenberg (2010)). If this asymmetric information leads to increased uncertainty then the trades of short sellers might be associated with increased volatility. Similarly, the mixture of distributions hypothesis also suggests that trading volume and the volatility of returns will be related as a consequence of their common dependence on latent information.

Accordingly, in order to test if the relation between short sales and volatility is a result of supply shocks in tandem with downward sloping demand curves, I again turn to an instrumental variables framework, this time using realized volatility as the dependent variable in the second stage equation. As before, I calculate realized volatility as the sum of squared five minute returns from TAQ and I measure the impact of short sales using the absolute value of changes in loan quantity. In order to ensure that my instruments are adequately correlated with the endogenous regressor, I also calculate the absolute difference of the instruments. Specifically, I use the absolute value of changes in *LoanSupply* and the square of the absolute change in *LoanSupply* as instruments.

I then estimate the following system of equations:

$$|\Delta LoanQty_{i,t}| = \beta_1|\Delta LoanSupply_{i,t}| + \beta_2\Delta LoanSupply^2_{i,t} + \beta_3 RV_{i,t-1} + \beta_4 RV_{i,w-1} + \beta_5 RV_{i,m-1} + \beta_6 Bid\text{-}Ask_{i,t} + \beta_7 Size_{i,m-1} + \beta_8 VIX_t + FE + \varepsilon_{i,t} \tag{7}$$

$$RV_{i,t} = \beta_1 \Delta \widehat{LoanQty}_{i,t} + \beta_2 RV_{i,t-1} + \beta_3 RV_{i,w-1} + \beta_4 RV_{i,m-1} + \beta_5 Bid\text{-}Ask_{i,t} + \beta_6 Size_{i,m-1} + \beta_7 VIX_t + FE + \varepsilon_{i,t} \tag{8}$$

where $|\Delta LoanSupply|$ and $\Delta LoanSupply^2$ are the excluded instruments and $\Delta\widehat{LoanQty}$ is the fitted value of $|\Delta LoanQty|$ from equation (7). The system uses shocks to loan supply to identify the impact that short sales (as measured by changes in daily loan quantity) have on contemporaneous realized volatility.

In order to account for the well-documented autoregressive property of volatility, I include three lags of realized volatility. Specifically, I adopt the Heterogeneous Autoregressive Realized Volatility (HAR-RV) class of models as developed by Corsi (2009).[18] Following Corsi (2009), I calculate the one day lag of realized volatility and I calculate weekly and monthly measures of past volatility as the time-series mean realized volatility over the previous five and twenty-two days, respectively, as shown in equations (9) and (10) below.

$$RV_{i,w-1} = \frac{1}{5}\sum_{j=1}^{5} RV_{t-j} \tag{9}$$

$$RV_{i,m-1} = \frac{1}{22}\sum_{j=1}^{22} RV_{t-j} \tag{10}$$

[18]Several other versions of the HAR-RV model have been proposed including models developed by Andersen, Bollerslev, and Diebold (2007) and Bollerslev, Kretschmer, Pigorsch, and Tauchen (2009). In this analysis, I focus on the parsimonious model first proposed by Corsi in 2004 and published in 2009.

The results from equations (7) and (8) are presented in Tables 7 and 8, respectively. I include a firm fixed effect in models 2 and 4 and in all models I use robust standard errors clustered by firm and date. The results in models 1 and 2 of Table 8 suggest that absolute changes in *LoanQty* are positively related to realized volatility, a result consistent with the predictions of the Miller (1977) model. The statistically significant coefficient of 0.2105 on *LoanQty* in model 1 suggests that a one standard deviation increase in the absolute change of *LoanQty* is associated with an increase in daily log realized volatility of 1.83%.[19] Moreover, as expected, this effect is similar in magnitude to the effect documented in Section 5.2 for the level of returns. Specifically, the 1.83% increase in log realized volatility represents approximately 3% of the unconditional standard deviation; for the level of returns, the 10.94 basis point effect discussed in Section 5.2 also represents approximately 3% of the unconditional standard deviation of daily returns.

As shown by Diether, Lee, and Werner (2009), short sellers may target firms as part of a number of different strategies. Accordingly, in models 3 and 4 I add three additional controls variables. As before, I add the daily bid-ask spread as a fraction of the closing mid-price (*Bid-Ask*) in order to control for liquidity effects documented by Diether, Lee, and Werner (2009) and I also add the log of the mean market capitalization for each firm over the previous month (*Size*) and the log of the daily CBOE volatility index for the S&P 500 (*VIX*).

The results with these additional control variables, shown in models 3 and 4, confirm the strong positive relation between short sales and volatility. The statistically significant coefficient of 0.2001 on *LoanQty* in model 4 of Table 8 suggests that a one standard deviation increase in the absolute change of *LoanQty* is associated with an increase in daily

[19] 1.83% = 0.2105 * 8.67%.

log realized volatility of 1.73%.[20] In other words, when short sellers trade, ceteris paribus, their trades lead to increased volatility.

To confirm that the instruments are valid, I display the results of the first stage regression in Table 7 and the results confirm that the absolute difference of *LoanSupply* does in fact have a statistically significant relation with absolute deviations in *LoanQty*.[21] Moreover, for each specification in Table 8, the Sargan–Hansen test fails to reject the null that the instruments are valid. Accordingly, I conclude that the instruments satisfy the necessary conditions and the inferences discussed above are valid.

In order to examine if the relation between short sales and volatility is a result of supply shifts in the presence of downward sloping demand curves in accordance with the Miller (1977) model, I then re-estimate the system shown in equations (7) and (8) separately for each of five subsamples based on analyst dispersion. Just as with the level of returns discussed in Section 5.2, if the predictions of the Miller model are true the relation between short sales and volatility should be highest in quintile 5 when market demand curves are more steeply downward sloping.

The results, presented in Table 9, confirm that short sales influence volatility the most when demand curves are more likely to have a steep downward slope. The statistically significant coefficient of 0.2397 in quintile 5 indicates that a one standard deviation increase in the absolute change of *LoanQty* is associated with an increase in daily log realized

[20] 1.73% = 0.2001 * 8.67%.

[21] While the F-test rejects the null that the excluded instruments are jointly equal to zero in each model, the magnitude of the test statistic is only marginally higher than the 10% critical value in some cases. Thus, in order to ensure that my results are not a result of weak instruments, I re-estimate the model using the Fuller-K estimator which allows for inference in the presence of weak instruments. The results, available upon request, are qualitatively unchanged.

volatility of 2.08%.[22] Moreover, just as with the level of returns shown in Table 5, the result is also strong for firms in the second highest quintile of analyst dispersion, although the effect is only marginally significant with a p-value of approximately 11%. By contrast, in quintile 1 the magnitude of the coefficient estimate on *LoanQty* is an order of magnitude smaller and it is neither economically nor statistically significant. In all models, the Sargan–Hansen test fails to reject the null that the instruments are valid. Similarly, in all models the first stage regression results, available upon request, confirm that the absolute difference of *LoanSupply* does in fact have a statistically significant relation with absolute deviations in *LoanQty*.

Overall, the results confirm that in the presence of heterogeneous beliefs, short sales lead to increased contemporaneous volatility. However, it is important to note this paper does not examine the general welfare implications of short sales. For instance, Boehmer, Jones, and Zhang (2009) find that volatility increases and liquidity decreases when short sales are banned during the financial crisis of 2008. They theorize that the short sales ban temporarily prevented a number of market participants, including hedge funds and proprietary trading desks, from providing liquidity via short sales. Similarly, Saffi and Sigurdsson (2010) find that stocks that are more difficult to short are associated with diminished price efficiency, a finding which suggests that short sales can improve the efficiency of prices. Thus, while the results in this study suggest that short sales lead to increased contemporaneous volatility, it is also possible that short sales help improve market quality and lead to lower volatility at longer horizons. Further research is necessary in order to understand the interaction of these countervailing forces.

[22] 2.08% = 0.2397 * 8.67%.

6. Conclusion

Using an equity lending database that contains information on the quantity of shares demanded and supplied, I test a previously unexplored implication that follows from models of heterogeneous beliefs: the idea that that short sales lead to increased volatility because they alter the effective supply of shares in the market. I use changes in the quantity of shares available to be borrowed as an instrument to identify the impact of supply shocks from short sales and I find evidence that these supply shocks have an effect on the level and the volatility of returns. I find that a one standard deviation increase (decrease) in the quantity of shares sold short is associated with a negative (positive) 10.94 basis point change in daily returns. Moreover, as a result of these supply shocks, I find evidence that short sales lead to increased contemporaneous volatility. Specifically, I find that a one standard deviation increase in the absolute change of shares sold short is associated with an increase in daily realized volatility of 1.83%.

In order to test if these findings are a result of downward sloping market demand curves as predicted by models of heterogeneous investor beliefs, I re-estimate the instrumental variable regressions using subsamples based on analyst dispersion, a proxy for heterogeneous beliefs. The Miller (1977) model predicts that supply curves will be more steeply downward sloping when dispersion in investor beliefs is higher. In accordance with the Miller (1977) theory, I find that the relation between short sales and both the level and volatility of returns is strongest in the highest quintile of analyst dispersion. The results provide strong evidence that when investors possess differing beliefs, the trades of short sellers lead to increased contemporaneous volatility.

Overall, the findings contribute to three different strands of the extant literature. First, the paper provides new empirical evidence that changes to asset supply can impact returns because market demand curves for stocks are downward sloping. Second, the paper confirms existing results that find a relation between heterogeneous investor beliefs and equity returns and moreover, it provides novel empirical evidence on *how* heterogeneous expectations influence returns and influence the shape of the market demand curve. Finally, the paper sheds new light on the relation between short sales and both the level and volatility of equity returns.

Figure 1
The Relation between Short Sales and Realized Volatility

Figure 1 displays a graph of *Realized Volatility* across *Loan Quantity* deciles. *Loan Quantity* is the quantity of shares on loan each day for each firm and is expressed as a percentage of shares outstanding and then grouped into deciles each day. *Realized Volatility* is calculated as the sum of squared 5 minute returns using TAQ data as in Andersen, Bollerslev, Diebold, and Ebens (2001). The solid line displays the mean value of *Realized Volatility* in each decile and the dashed line displays the median value.

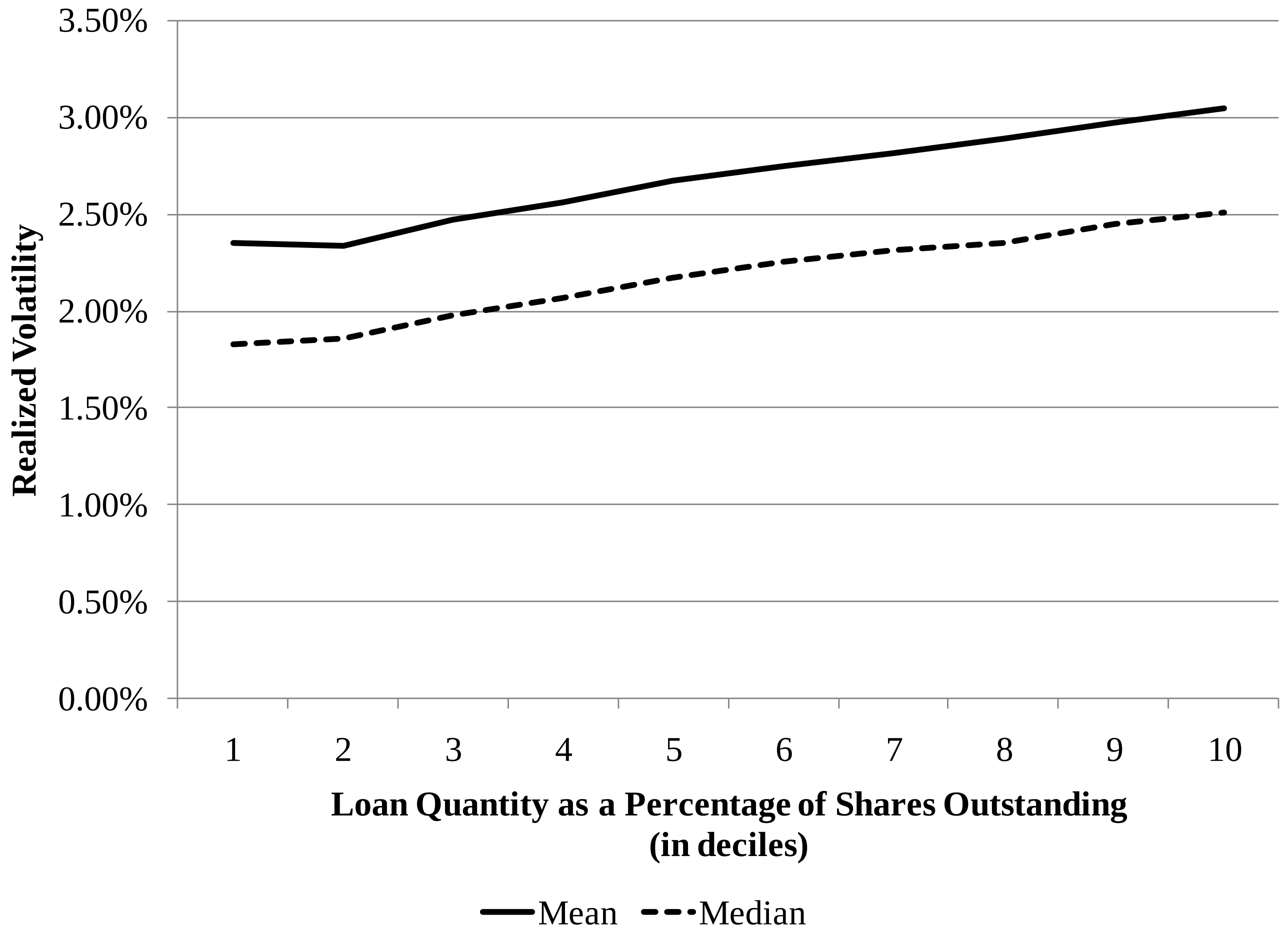
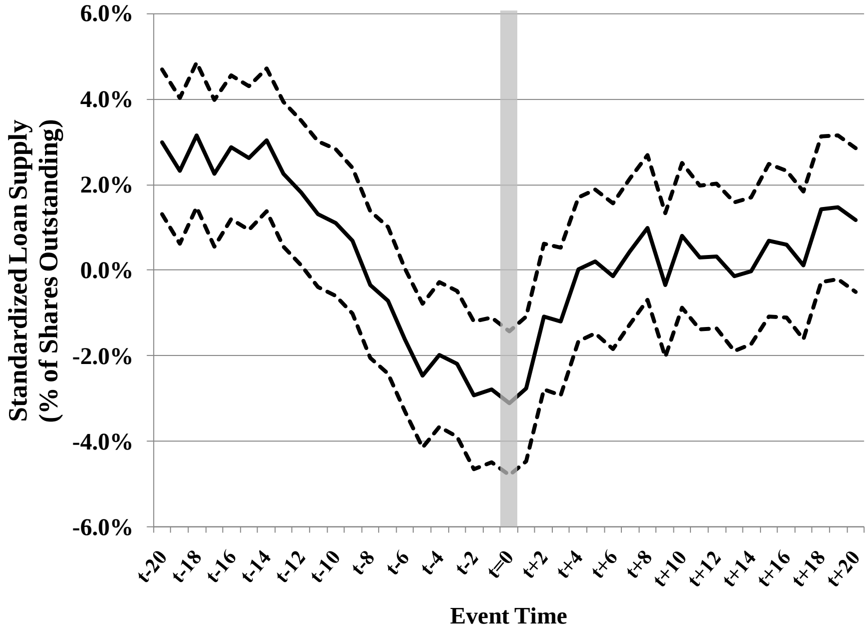


Figure 2
Equity Lending around Ex-Dividend Dates

Figure 2 examines the equity lending market in event time around ex-dividend dates. As a consequence of dividend taxation policies (e.g., Thornock (2010)), many lenders recall shares prior to the ex-dividend date. Panel A displays standardized loan supply as a percentage of shares outstanding in the twenty days before and after the ex-dividend date while Panel B examines lending fees (in deciles) in the twenty days before and after the ex-dividend date. In each panel, the solid line represents the mean value while the dotted lines represent the 10% confidence bounds.

Panel A: Loan Supply around Ex-Dividend Dates



Panel B: Lending Fee around Ex-Dividend Dates

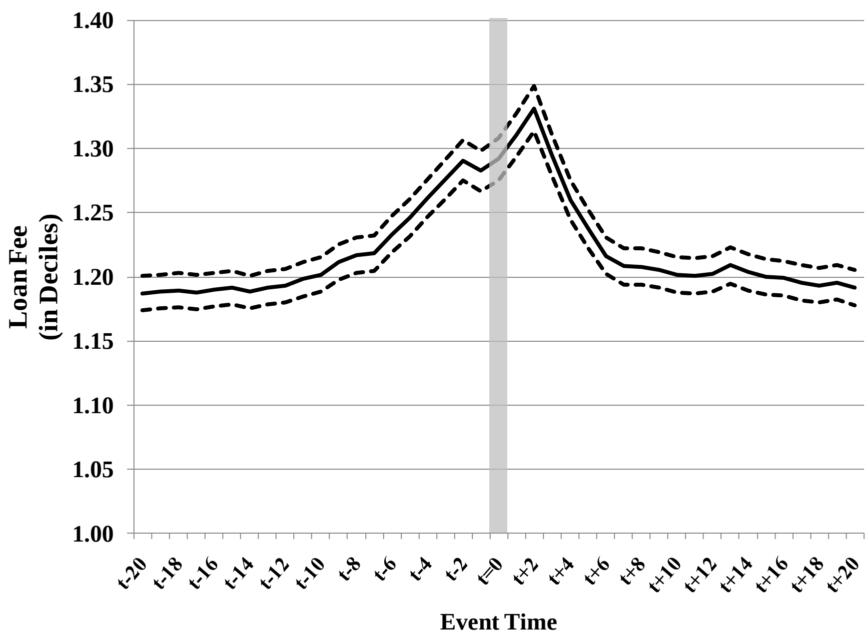


Table 1
Summary Statistics

The database contains 1,157,016 daily observations over the period January 1, 2007 through December 31, 2009. Equity loan market data is discussed in detail in Section 4 of the text. *Loan Quantity* is the quantity of shares on loan each day for each firm and *Loan Supply Quantity* is the quantity of shares available to be borrowed each day for each firm. *Utilization Rate* is the *Loan Quantity* as a percentage of the *Loan Supply Quantity* and *Price Decile* represents the cost of borrowing shares, measured in deciles. *Short Interest* data is from Compustat and *Short Volume, Daily Return, Shares Outstanding, and Volume* are from CRSP. *B/M* is the book to market ratio for each firm as of the end of the previous quarter from Compustat and *Size* is the market capitalization calculated from daily CRSP data. *Realized Volatility* is calculated as the sum of squared 5 minute returns using TAQ data as in Andersen, Bollerslev, Diebold, and Ebens (2001). Panel A summarizes the equity loan market data at the firm level and Panel B provides an overview of the correlation between the total quantity on loan in the equity loan market for a given stock and two different measures of short sales, short volume and short interest. Panel C summarizes the firm-level characteristics of the sample.

Variable	**Mean**	**Median**	**1st Percentile**	**99th Percentile**	**Standard Deviation**
Panel A: Equity Loan Market					
Loan Quantity	9.24m	4.42m	0.03m	77.83m	22.03m
Loan Quantity / Shares Out	6.51%	4.33%	0.08%	30.19%	6.71%
|Δ(Loan Quantity / Shares Out)|	5.66%	2.65%	0.01%	54.13%	8.67%
Loan Supply Quantity	63.05m	23.87m	0.23m	707.37m	147.17m
Loan Supply Quantity / Shares Out	26.13%	26.77%	0.71%	48.67%	10.49%
Utilization Rate	22.41%	15.71%	0.37%	84.64%	20.80%
Price Decile	1.24	1.00	1.00	6.00	0.92
Panel B: Relation Between Loan Quantity and Short Sales Measures					
Correlation (*Loan Qty*, *Short Volume*)	0.11	0.10	-0.39	0.99	0.19
Correlation (*Loan Qty*, *Short Interest*)	0.70	0.78	-0.57	0.99	0.26
Panel C: Firm Characteristics					
B/M	0.56	0.45	0.03	2.22	1.14
Size	$8.96b	$2.58b	$0.31b	$129.69b	$24.82b
Daily Return	0.05%	0.00%	-10.19%	11.04%	3.67%
Volume / Shares Out	1.43%	1.00%	0.08%	7.61%	1.86%
Realized Volatility	2.68%	2.17%	0.65%	9.76%	1.99%

Table 2
Equity Loan Supply as a Candidate Instrument

Table 2 displays the results of four different panel data regressions of the form:

$$y_{i,t} = \alpha + \beta_1 News_{i,t} + \beta_2 LoanQty_{i.t} + \beta_3 Bid\text{-}Ask_{i,t} + \beta_4 B/M_{i,q-1} + \beta_5 Size_{i,q-1} + \beta_6 MarketRet_{t-1} + \beta_7 Ret_{i,t-1} + \beta_8 Ret_{i,t-2} + FE + \varepsilon_{i,t}$$

where the dependent variable $y_{i,t}$ is: (1) $LoanSupply_{i,t}$, (2) $LoanSupply^2_{i,t}$,(3) $Returns_{i,t}$, or (4) $Volume_{i,t}$. *Returns* and *Volume* (expressed as a percentage of shares outstanding) are from CRSP while *LoanSupply* is discussed in detail in Section 4 of the text. *News* measures the number of negative words in a news article as a fraction of total words according to the negative word list developed by Loughran and McDonald (2011) and the data is from the Dow Jones News Archive as in Engelberg et al. (2010). *LoanQty* is the quantity of shares on loan as a fraction of shares outstanding. *Bid-Ask Spread* is calculated daily as a fraction of the closing mid-price. *B/M* is the log of the book to market ratio for each firm as of the end of the previous quarter from Compustat and *Size* is the log of the mean market capitalization for each firm over the previous quarter from CRSP. $MarketRet_{t-1}$ is the lagged daily value-weighted market return from CRSP and Ret_{t-1} is the lagged return for each firm from CRSP. T-statistics are below the parameter estimates in italics and were calculated using robust standard errors clustered by firm with firm fixed effects. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significant at the 10% level.

	Dependent Variable			
Explanatory Variable	**Loan Supply**	**Loan Supply Squared**	**Returns**	**Volume**
Intercept	0.0274	0.0007	0.0457***	6.8022***
	(0.56)	*(0.01)*	*(17.25)*	(7.06)
News	0.0216	0.0029	-0.0276***	6.7934***
	(1.04)	*(0.21)*	*(-6.73)*	(11.05)
Loan Qty	0.3828***	0.2941***	0.0031***	5.1968***
	(15.57)	*(5.21)*	*(3.37)*	(13.01)
Bid-Ask Spread	-0.0866***	-0.0357*	0.0288**	7.3442***
	(-3.26)	*(-1.77)*	*(2.20)*	(4.30)
B/M	-0.0006	-0.0042	0.0007***	0.1838***
	(-0.21)	*(-1.06)*	*(4.58)*	(3.92)
Size	0.0141***	0.0038	-0.0030***	-0.3712***
	(4.08)	*(0.77)*	*(-16.25)*	(-5.61)
Market Ret_{t-1}	-0.0147***	-0.0127***	1.1392***	-0.0459
	(-6.78)	*(-3.82)*	*(102.40)*	(-0.59)
Ret_{t-1}	-0.0063***	0.0014	-0.0110***	-0.5622***
	(-3.33)	*(0.15)*	*(-3.81)*	(-2.95)
Ret_{t-2}	-0.0063***	-0.0057*	-0.0057***	-0.7822***
	(-3.78)	*(-1.90)*	*(-2.93)*	(-6.88)
N	978,598	978,598	978,716	978,716
R^2	0.145	0.014	0.361	0.033
Firm FE	Yes	Yes	Yes	Yes

Table 3
First Stage: The Relation between Equity Loans and the Level of Returns

Table 3 displays the results of the first stage of a two stage instrumental variables panel regression examining the relation between equity loan quantity and the level of returns. The first stage model is given by:

$$LoanQty_{i,t} = \beta_1 LoanSupply_{i,t} + \beta_2 LoanSupply^2_{i,t} + \beta_3 Bid\text{-}Ask_{i,t} + \beta_4 B/M_{i,q-1} + \beta_5 Size_{i,q-1} + \beta_6 MarketRet_{t-1} + \beta_7 Ret_{i,t-1} + \beta_8 Ret_{i,t-2} + FE + \varepsilon_{i,t}$$

LoanQty is the quantity of shares on loan each day for each firm, expressed as a fraction of shares outstanding. *LoanSupply* and $LoanSupply^2$ are the excluded instruments. *LoanSupply* is the quantity of shares available to be borrowed each day for each firm, expressed as a fraction of shares outstanding, and $LoanSupply^2$ is the square of *LoanSupply*. *Bid-Ask Spread* is calculated daily as a fraction of the closing mid-price. *B/M* is the log of the book to market ratio for each firm as of the end of the previous quarter from Compustat and *Size* is the log of the mean market capitalization for each firm over the previous quarter from CRSP. $MarketRet_{t-1}$ is the lagged value weighted return on the market from CRSP and Ret_{t-1} is the lagged return for each firm from CRSP. Firm fixed effects are included in models 2 and 4. The *F Statistic* is the Angrist-Pischke multivariate F test of excluded instruments. T-statistics are below the parameter estimates in italics and were calculated using robust standard errors clustered by firm and date. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significant at the 10% level.

Explanatory Variable	**Model (1)**	**(2)**	**(3)**	**(4)**
Loan Supply	0.0002***	0.0004***	0.0002***	0.0004***
	(9.86)	*(11.42)*	*(11.12)*	*(11.83)*
Loan Supply^2	9.89×10^{-9}	-4.49×10^{-8}***	-4.89×10^{-9}	-4.93×10^{-8}***
	(0.30)	*(-4.73)*	*(-0.25)*	*(-6.66)*
Bid-Ask Spread			0.2234	0.1780
			(1.24)	*(1.50)*
B/M			-0.0116***	-0.0055*
			(-6.43)	*(-1.72)*
Size			-0.0186***	-0.0038
			(-8.97)	*(-0.87)*
Market Ret_{t-1}			-0.0442*	-0.0395**
			(-1.82)	*(-2.46)*
Ret_{t-1}			0.0077	0.0140**
			(0.72)	*(2.10)*
Ret_{t-2}			-0.0066	0.0010
			(-0.97)	*(0.28)*
N	900,232	900,232	820,759	820,759
F Statistic	70.43***	66.39***	67.02***	65.85***
Firm FE	No	Yes	No	Yes

Table 4

Second Stage: The Relation between Equity Loans and the Level of Returns

Table 4 displays the results of the second stage of a two stage instrumental variables panel regression examining the relation between equity loan quantity and the level of returns. The second stage model is given by:

$$Ret_{i,t} = \beta_1 \widehat{LoanQty}_{i,t} + \beta_2 Bid\text{-}Ask_{i,t} + \beta_3 B/M_{i,q-1} + \beta_4 Size_{i,q-1} + \beta_5 MarketRet_{t-1} + \beta_6 Ret_{i,t-1} + \beta_7 Ret_{i,t-2} + FE + \varepsilon_{i,t}$$

where *Ret* is the daily return for each stock from CRSP and $\widehat{LoanQty}$ is the fitted value of *LoanQty* from the first stage regression shown in Table 3. *Bid-Ask Spread* is calculated daily as a fraction of the closing mid-price. *B/M* is the log of the book to market ratio for each firm as of the end of the previous quarter from Compustat and *Size* is the log of the mean market capitalization for each firm over the previous quarter from CRSP. $MarketRet_{t-1}$ is the lagged value weighted return on the market from CRSP and Ret_{t-1} is the lagged return for each firm from CRSP. Firm fixed effects are included in models 2 and 4. The Sargan – Hansen statistic is a test of overidentifying restrictions under the null that the excluded instruments are suitably independent of the error process. T-statistics are below the parameter estimates in italics and were calculated using robust standard errors clustered by firm and date. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significant at the 10% level.

Explanatory Variable	**Model (1)**	**(2)**	**(3)**	**(4)**
Loan Qty	-0.0110***	-0.0359***	-0.0223***	-0.0163**
	(-2.27)	*(-3.03)*	*(-2.67)*	*(-2.00)*
Bid-Ask Spread			-0.2253***	-0.2327***
			(-2.81)	*(-2.89)*
B/M			0.0003	0.0005
			(1.08)	*(0.80)*
Size			-0.0010***	-0.0054***
			(-3.46)	*(-4.02)*
Market Ret_{t-1}			-0.0891***	-0.0883**
			(-2.49)	*(-2.49)*
Ret_{t-1}			-0.0067	-0.0098
			(-1.04)	*(-1.55)*
Ret_{t-2}			-0.0396*	-0.0425*
			(-1.75)	*(-1.87)*
N	900,232	900,232	820,759	820,759
Sargan – Hansen	1.5750	0.9550	2.5600	2.4050
P-value	*0.21*	*0.33*	*0.11*	*0.12*
Firm FE	No	Yes	No	Yes

Table 5
Second Stage: The Relation between Equity Loans and the Level of Returns
- By Dispersion Quintiles -

Table 5 displays the results of the second stage of a two stage instrumental variables panel regression examining the relation between equity loan quantity and the level of returns. Analyst dispersion is ranked into quintiles and then the regression is estimated separately for each analyst dispersion quintile. The second stage model is given by:

$$Ret_{i,t} = \beta_1 \widehat{LoanQ}ty_{i,t} + \beta_2 Bid\text{-}Ask_{i,t} + \beta_3 B/M_{i,q-1} + \beta_4 Size_{i,q-1} + \beta_5 MarketRet_{t-1} + \beta_6 Ret_{i,t-1} + \beta_7 Ret_{i,t-2} + FE + \varepsilon_{i,t}$$

where *Ret* is the daily return for each stock from CRSP and $\widehat{LoanQ}ty$ is the fitted value of *LoanQty* from the first stage regression. Analyst dispersion is defined as in Diether, Malloy, and Scherbina (2002). *Bid-Ask Spread* is calculated daily as a fraction of the closing mid-price. *B/M* is the log of the book to market ratio for each firm as of the end of the previous quarter from Compustat and *Size* is the log of the mean market capitalization for each firm over the previous quarter from CRSP. $MarketRet_{t-1}$ is the lagged value weighted return on the market from CRSP and Ret_{t-1} is the lagged return for each firm from CRSP. Firm fixed effects are included in all models. The Sargan – Hansen statistic is a test of overidentifying restrictions under the null that the excluded instruments are suitably independent of the error process. T-statistics are below the parameter estimates in italics and were calculated using robust standard errors clustered by firm and date. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significant at the 10% level.

Explanatory	**Dispersion Rank (1=Low, 5=High)**				
Variable	**Rank = 1**	**Rank = 2**	**Rank = 3**	**Rank = 4**	**Rank = 5**
Loan Qty	-0.0070	0.0015	-0.0014	-0.0261*	-0.0411***
	(-0.67)	*(0.15)*	*(-0.10)*	*(-1.69)*	*(-3.04)*
Bid-Ask Spread	-0.2764**	-0.1237**	-0.2136**	-0.3977***	-0.2536***
	(-2.53)	*(-2.56)*	*(-1.99)*	*(-3.60)*	*(-3.35)*
B/M	0.0019**	0.0022**	0.0029**	0.0013**	0.0009
	(2.06)	*(2.28)*	*(2.42)*	*(1.99)*	*(0.97)*
Size	-0.0048***	-0.0047***	-0.0045***	-0.0057***	-0.0058***
	(-3.41)	*(-3.48)*	*(-3.60)*	*(-4.18)*	*(-5.54)*
Market Ret_{t-1}	-0.0896***	-0.1085***	-0.0967***	-0.0539	-0.0725
	(-4.03)	*(-4.11)*	*(-3.24)*	*(-1.06)*	*(-1.30)*
Ret_{t-1}	-0.0236**	-0.0023	-0.0264**	-0.0285***	0.0038
	(-2.40)	*(-0.29)*	*(-1.98)*	*(-4.59)*	*(0.62)*
Ret_{t-2}	-0.0574***	-0.0581**	-0.0533**	-0.0464**	-0.0260
	(-2.93)	*(-2.48)*	*(-2.33)*	*(-1.97)*	*(-1.13)*
N	165,146	166,878	165,070	163,997	159,666
Sargan – Hansen	1.18	0.62	2.12	0.03	1.77
P-value	*0.28*	*0.43*	*0.15*	*0.87*	*0.18*
Firm FE	Yes	Yes	Yes	Yes	Yes

Table 6
The Relation between Equity Loans and Conditional Volatility

Table 6 displays the mean coefficient estimates from 1,468 time series GARCH(1,1) regressions examining the relation between equity loan quantity and the volatility of returns according to the following models:

$$ret_t = m + \sqrt{h_t}\varepsilon_t$$

$$h_t = \omega + \alpha(r_{t-1} - m)^2 + \beta h_{t-1} + \gamma|\Delta LoanQty_t|$$

Regressions are estimated separately for each firm and the mean of the cross-sectional estimates is reported. Model 1 is a standard GARCH(1,1) while Model 2 augments the standard model by including an additional regressor, $|\Delta LoanQty|$, in the volatility equation. $|\Delta LoanQty|$ is the absolute value of the percentage change in quantity of shares on loan each day for each firm. T-statics are reported below the parameter estimates and were calculated using the standard deviation of the cross-sectional estimates as in Coval and Shumway (2005) and Kolasinski et al. (2010). *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significant at the 10% level.

Explanatory Variable	Mean of Estimates	
	(1)	**(2)**
m	9.77×10^{-4}***	9.29×10^{-4}***
	(36.01)	*(34.94)*
ω	6.34×10^{-5}***	4.65×10^{-5}***
	(5.91)	*(10.61)*
ARCH (α)	0.1331***	0.1388***
	(45.40)	*(50.55)*
GARCH (β)	0.8298***	0.8024***
	(202.12)	*(166.96)*
Loan Qty (γ)		8.20×10^{-6}***
		(13.50)

Table 7

First Stage: The Relation between Equity Loans and Realized Volatility

Table 7 displays the results of the first stage of a two stage instrumental variables panel regression examining the relation between equity loan quantity and the volatility of returns. The first stage model is given by:

$$|\Delta LoanQty_{i,t}| = \beta_1|\Delta LoanSupply_{i,t}| + \beta_2 \Delta LoanSupply_{i,t}^2 + \beta_3 RV_{i,t-1} + \beta_4 RV_{i,w-1} + \beta_5 RV_{i,m-1} + \beta_6 Bid\text{-}Ask_{i,t} + \beta_7 Size_{i,m-1} + \beta_8 VIX_t + FE + \varepsilon_{i,t}$$

$|\Delta LoanQty|$ is the absolute percentage change in the quantity of shares on loan each day for each firm, $|\Delta \text{LoanSupply}|$ and $\Delta LoanSupply^2$ are the excluded instruments. $|\Delta LoanSupply|$ is the absolute percentage change in the quantity of shares available to be borrowed each day for each firm and $\Delta LoanSupply^2$ is the square of $\Delta LoanSupply$. $RV_{i,t-1}$ is the lagged realized volatility for each firm, $RV_{i,w-1}$ is the mean realized volatility over the previous week, and $RV_{i,m-1}$ is the mean realized volatility over the previous month, as in Corsi (2009). *Bid-Ask Spread* is calculated daily as a fraction of the closing mid-price. *Size* is the log of the mean market capitalization for each firm over the previous month from CRSP and *VIX* is the log of the daily CBOE volatility index for the S&P 500. Firm fixed effects are included in models 2 and 4. The *F Statistic* is the Angrist-Pischke multivariate F test of excluded instruments. T-statistics are below the parameter estimates in italics and were calculated using robust standard errors clustered by firm and date. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significant at the 10% level.

Explanatory Variable	**Model (1)**	**(2)**	**(3)**	**(4)**
Loan Supply	0.5052***	0.4963***	0.5251***	0.4963***
	(4.09)	*(3.92)*	*(4.26)*	*(3.92)*
Loan Supply^2	-0.0200***	-0.0196***	-0.0209***	-0.0196***
	(-4.93)	*(-4.68)*	*(-5.17)*	*(-4.68)*
RV_{t-1}	0.0099***	0.0105***	0.0095***	0.0102***
	(4.75)	*(5.53)*	*(4.77)*	*(5.20)*
RV_{w-1}	0.0128***	0.0134***	0.0087**	0.0111***
	(3.44)	*(3.85)*	*(2.53)*	*(3.40)*
RV_{m-1}	-0.0325***	-0.0251***	-0.0252***	-0.0225***
	(-7.70)	*(-6.58)*	*(-5.45)*	*(-5.39)*
Bid-Ask Spread			0.5143**	0.1644
			(2.45)	*(1.29)*
Size			0.0110***	0.0079***
			(14.22)	*(3.65)*
VIX			0.0115***	0.0043
			(3.43)	*(1.39)*
N	859,220	859,220	859,220	859,220
F Statistic	16.12***	14.62***	18.00***	14.58***
Firm FE	No	Yes	No	Yes

Table 8

Second Stage: The Relation between Equity Loans and Realized Volatility

Table 8 displays the results of the second stage of a two stage instrumental variables panel regression examining the relation between equity loan quantity and the volatility of returns. The second stage model is given by:

$$RV_{i,t} = \beta_1 \Delta \widehat{LoanQty}_{i,t} + \beta_2 RV_{i,t-1} + \beta_3 RV_{i,w-1} + \beta_4 RV_{i,m-1} + \beta_5 Bid\text{-}Ask_{i,t} + \beta_6 Size_{i,m-1} + \beta_7 VIX_t + FE + \varepsilon_{i,t}$$

where *RV* is the daily realized volatility for each stock calculated using 5 minute returns from TAQ as in Andersen, Bollerslev, Diebold, and Ebens (2001) and $\Delta \widehat{LoanQty}$ is the fitted value of $|\Delta LoanQty_{i,t}|$ from the first stage regression shown in Table 8. $RV_{i,t-1}$ is the lagged realized volatility for each firm, $RV_{i,w-1}$ is the mean realized volatility over the previous week, and $RV_{i,m-1}$ is the mean realized volatility over the previous month, as in Corsi (2009). *Bid-Ask Spread* is calculated daily as a fraction of the closing mid-price. *Size* is the log of the mean market capitalization for each firm over the previous month from CRSP and *VIX* is the log of the daily CBOE volatility index for the S&P 500. Firm fixed effects are included in models 2 and 4. The Sargan – Hansen statistic is a test of overidentifying restrictions under the null that the excluded instruments are suitably independent of the error process. T-statistics are below the parameter estimates in italics and were calculated using robust standard errors clustered by firm and date. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significant at the 10% level.

Explanatory Variable	**Model (1)**	**(2)**	**(3)**	**(4)**
ΔLoan Qty	0.2105**	0.1802*	0.2440**	0.2001**
	(2.09)	*(1.81)*	*(2.43)*	*(1.98)*
RV_{t-1}	0.3050***	0.3040***	0.2966***	0.2849***
	(20.35)	*(20.33)*	*(20.35)*	*(20.44)*
RV_{w-1}	0.4388***	0.4379***	0.4180***	0.3933***
	(15.53)	*(15.48)*	*(15.64)*	*(15.56)*
RV_{m-1}	0.2216***	0.2056***	0.1722***	0.0718**
	(7.72)	*(7.07)*	*(5.96)*	*(2.43)*
Bid-Ask Spread			4.7549***	4.7841***
			(4.13)	*(4.04)*
Size			-0.0101***	-0.0069
			(-5.93)	*(-0.74)*
VIX			0.1053***	0.2217***
			(7.60)	*(13.36)*
N	859,220	859,220	859,220	859,220
Sargan – Hansen	0.696	0.506	1.223	1.211
P-value	*0.40*	*0.48*	*0.27*	*0.27*
Firm FE	No	Yes	No	Yes

Table 9
Second Stage: The Relation between Equity Loans and Realized Volatility
- By Dispersion Quintiles -

Table 9 displays the results of the second stage of a two stage instrumental variables panel regression examining the relation between equity loan quantity and the volatility of returns. Analyst dispersion is ranked into quintiles and then the regression is estimated separately for each analyst dispersion quintile. The second stage model is given by:

$$RV_{i,t} = \beta_1 \Delta\widehat{LoanQty}_{i,t} + \beta_2 RV_{i,t-1} + \beta_3 RV_{i,w-1} + \beta_4 RV_{i,m-1} + \beta_5 Bid\text{-}Ask_{i,t} + \beta_6 Size_{i,m-1} + \beta_7 VIX_t + FE + \varepsilon_{i,t}$$

where *RV* is the daily realized volatility for each stock calculated using 5 minute returns from TAQ as in Andersen, Bollerslev, Diebold, and Ebens (2001) and $\Delta\widehat{LoanQty}$ is the fitted value of $|\Delta LoanQty_{i,t}|$ from the first stage regression. Analyst dispersion is defined as in Diether, Malloy, and Scherbina (2002). $RV_{i,t-1}$ is the lagged realized volatility for each firm, $RV_{i,w-1}$ is the mean realized volatility over the previous week, and $RV_{i,m-1}$ is the mean realized volatility over the previous month, as in Corsi (2009). *Bid-Ask Spread* is calculated daily as a fraction of the closing mid-price. *Size* is the log of the mean market capitalization for each firm over the previous month from CRSP and *VIX* is the log of the daily CBOE volatility index for the S&P 500. Firm fixed effects are included in all models. The Sargan – Hansen statistic is a test of overidentifying restrictions under the null that the excluded instruments are suitably independent of the error process. T-statistics are below the parameter estimates in italics and were calculated using robust standard errors clustered by firm and date. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significant at the 10% level.

Explanatory Variable	**Dispersion Rank (1=Low, 5=High)**				
	Rank = 1	**Rank = 2**	**Rank = 3**	**Rank = 4**	**Rank = 5**
ΔLoan Qty	-0.0176	0.2437	0.0964*	0.3272	0.2397**
	(-0.08)	*(1.52)*	*(1.73)*	*(1.59)*	*(2.16)*
RV_{t-1}	0.2729***	0.2712***	0.2700***	0.2839***	0.2892***
	(18.12)	*(18.30)*	*(18.87)*	*(20.34)*	*(21.83)*
RV_{w-1}	0.3565***	0.3667***	0.3790***	0.3670***	0.3783***
	(13.55)	*(13.77)*	*(14.64)*	*(14.58)*	*(16.24)*
RV_{m-1}	0.0159	0.0218	-0.0092	0.0275	0.0730***
	(0.46)	*(0.61)*	*(-0.29)*	*(0.91)*	*(2.65)*
Bid-Ask Spread	7.7324***	2.1704	6.0002***	5.7912***	4.3447***
	(8.14)	*(1.39)*	*(4.85)*	*(8.89)*	*(4.33)*
Size	0.0516***	0.0287	0.0131	0.0036	-0.0253***
	(2.68)	*(1.59)*	*(0.95)*	*(0.31)*	*(-3.04)*
VIX	0.3154***	0.3130***	0.3212***	0.2900***	0.2303***
	(13.29)	*(11.42)*	*(13.89)*	*(14.19)*	*(11.87)*
N	173,670	171,572	173,138	171,756	169,084
Sargan – Hansen	0.385	0.239	1.689	1.961	0.098
P-value	*0.53*	*0.63*	*0.19*	*0.16*	*0.75*
Firm FE	Yes	Yes	Yes	Yes	Yes

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