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Inter-temporal variation in the illiquidity premium[☆]

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ABSTRACT

We find evidence of a systematic link between monetary conditions and inter-temporal variation in the price of liquidity. Specifically, following an expansive monetary policy shift, funding conditions improve and market-wide liquidity increases, which is especially beneficial for illiquid securities. The improved liquidity and funding conditions reduce the returns required for holding illiquid securities. Consequently, illiquid stocks experience relatively large price increases when monetary conditions become expansive, and thus, the measured return spread between illiquid and liquid stocks expands substantially. Overall, our evidence supports the claim that the price of asset liquidity is dependent on monetary conditions.

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1. Introduction

In their seminal work, Amihud and Mendelson (1986) relate asset prices to stock liquidity. The authors identify a significant positive relation between expected security returns and illiquidity, an illiquidity premium, which has been confirmed by numerous subsequent researchers.[1] Despite the widespread recognition of liquidity's relevance for asset prices, liquidity has not been consistently incorporated into asset pricing models. This omission may be at least partially attributed to the existing uncertainty regarding the manner in which prices reflect asset liquidity. The relation between security returns and illiquidity contains a significant time-varying component, which implies an underlying factor influences liquidity pricing. Recent research has been directed at providing possible explanations for the inter-temporal variation in the price of liquidity. We contribute to this literature by investigating whether the variation in liquidity pricing is systematically linked to macroeconomic changes; more specifically, changes in monetary conditions.

We present an argument that relates monetary conditions, liquidity, and security returns. Our argument follows from the recent theories of Acharya and Pedersen (2005) and Brunnermeier and Pedersen (2009) and is based on the following major theme. Monetary expansions coincide with periods of increasing liquidity and expansion in funding available for purchasing illiquid

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[1] See, for example, Amihud and Mendelson (1989), Brennan and Subrahmanyam (1996), Hu (1997), Brennan, Chordia, and Subrahmanyam (1998), Datar, Naik, and Radcliffe (1998), Amihud (2002), Jones (2002), and Nguyen, Mishra, and Prakash (2005).

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securities. A market-wide increase in liquidity reduces the required returns for providing liquidity and for bearing the costs and risks of holding illiquid stocks, which causes a relatively large increase in the price of illiquid stocks. As a consequence, the most illiquid stocks benefit the most from the increased availability of funds and they experience the largest increase in price and liquidity. The empirical outcome is that the observed return spread between illiquid and liquid stocks is higher in periods of expansive monetary policy. In the following sections, we separate the theme above into two interrelated, yet independent issues. We relate each issue to empirical evidence presented in our paper.

Through several alternative analyses, we first examine the relation of monetary conditions to the availability of funding and security liquidity. Our findings suggest that during periods of expansive monetary policy, the aggregate availability of funds increases and security liquidity improves. Specifically, we observe relatively large increases in bank reserves and the monetary base during expansive monetary periods. Furthermore, we observe a general increase in aggregate market liquidity during expansive monetary conditions. Aggregate liquidity deteriorates before, and improves after, expansive Federal Reserve policy shifts. By refining the analysis, we show that improvements in liquidity are greatest for the most illiquid stocks.

Taken together, these findings support the contention that funding conditions improve and capital becomes more abundant during expansive monetary periods. Improved funding conditions have a number of benefits for financial markets. An increase in the availability of capital reduces the severity of liquidity shocks and better insulates institutions from future liquidity shocks. For example, since capital can substitute for selling stocks, an influx of capital reduces the need to sell stocks at abnormally low prices to meet a client's demands for cash conversion. Consequently, increases in capital reduce risk aversion and allow traders to establish riskier positions. Thus, speculators and market makers become more willing and able to hold relatively illiquid securities when capital becomes more abundant. The benefits of increased capital are most pronounced for stocks that are least liquid.

The second major issue we address is the relation between monetary conditions and investor pricing of liquidity. An illiquidity premium arises because investors demand compensation for larger price impacts of trading and larger effective costs of trading illiquid securities. In times of improving market liquidity, which we find coincide with expansive monetary periods, the costs of providing liquidity and the risks and costs of holding illiquid securities are reduced. This reduction in risks and costs reduces the return premium demanded by investors. Because the reduction in illiquidity costs is greatest for the most illiquid stocks, theory predicts that the reduction in the return premium demanded by investors should also be greatest for the most illiquid stocks. We find that the return differential between illiquid and liquid stocks fluctuates around expansive monetary policy shifts in direct correspondence with liquidity and funding conditions, as identified in our first set of analyses. Specifically, as funding conditions improve, following an expansive policy shift, the price of illiquid stocks advances relative to liquid stocks. Thus, the observed difference between the returns of illiquid and liquid stocks expands.

Overall, our evidence supports the contention that recognizing the relevance of monetary policy is crucial to understanding the role that liquidity plays in asset pricing. Understanding the process by which investors establish a price for asset liquidity is instrumental for determining whether liquidity is a priced factor. Failure to properly specify the model incorporating asset liquidity could result in an erroneous rejection of liquidity as a priced factor. Our findings suggest that the price of liquidity is highly conditional on prevailing monetary policy. These findings are consistent with the theory advanced by Acharya and Pedersen (2005) and Brunnermeier and Pedersen (2009), but extend these efforts by proposing instrumental variables that are shown to explain the temporal variation in the price of liquidity. Our findings provide a necessary step forward in determining whether asset liquidity should be integrated into asset pricing models, and further, our findings provide an economic structure to guide the specification of such a model.

The rest of the paper proceeds as follows. In Section 2, we discuss related research and provide details on the paper's contribution and motivation. Section 3 presents the data and describes the variables used in the analysis. Section 4 contains a discussion of our empirical findings. Section 5 concludes the paper.

2. Related research

Within the theoretical literature, Amihud and Mendelson (1986) and Acharya and Pedersen (2005) explain variation in asset demand relative to asset illiquidity. In equilibrium, for a market with trading frictions, Amihud and Mendelson show that assets with higher bid-ask spreads are allocated to longer horizon investors, and expected stock returns are increasing in the bid-ask spread. Thus, a long-horizon investor is able to extract rents because of a short-horizon investor's (excess) demand for liquidity. In the model of Acharya and Pedersen (2005), agents expect to incur an uncertain illiquidity cost when selling a security. An illiquidity premium in stock returns is demanded because investors are concerned about the costs and risks of holding illiquid assets. Supporting these theoretical predictions, both studies also find empirical evidence for an illiquidity premium in stock returns.

The existence of an unconditional illiquidity premium, such as that found by Amihud and Mendelson (1986) and Acharya and Pedersen (2005), has been shown by several researchers.[2] Our focus is on determining whether the illiquidity premium that has been reported by other

[2] Examples of papers that dispute the relation between illiquidity or illiquidity risk and stock returns include Spiegel and Wang (2005), Hasbrouck (2009), and Vassalou, Chen, and Zhou (2006).

researchers has time variation that can be explained by changes in monetary conditions. Although much empirical research has focused on an unconditional illiquidity premium, the models of Amihud and Mendelson (1986) and Acharya and Pedersen (2005) also imply a conditional illiquidity premium.

The models of Amihud and Mendelson (1986) and Acharya and Pedersen (2005) predict that expected returns will fluctuate with a security's expected illiquidity costs. Specifically, during periods that witness an influx of liquidity, liquidity becomes less valued by market participants. Thus, the expected returns for bearing the costs and risks associated with illiquidity decline as liquidity improves, which results in a reduction in the illiquidity premium. Throughout the paper we refer to the illiquidity premium as the required return premium for holding illiquid stocks rather than liquid stocks. Thus, the illiquidity premium decreases when the price of illiquid stocks, relative to liquid stocks, increases or when the return to a zero-cost portfolio (long illiquid and short liquid stocks) increases.

Our analysis also utilizes a theoretical model developed by Brunnermeier and Pedersen (2009), to motivate the source of time variation in the illiquidity premium in returns across individual stocks. We contend that the source of time variation is an improvement in liquidity during monetary expansions. Brunnermeier and Pedersen's model is based on "customers" and "speculators" that trade assets and "financiers" that finance speculators' positions. According to the model, markets are more liquid when there is greater funding available to risk-neutral "speculators"[3] or greater funding liquidity. Whenever possible, speculators prefer to hold illiquid securities, as illiquid securities offer "the greatest profit per capital use." Thus, speculators provide liquidity for the market and can improve market-wide liquidity when they receive more funding. However, adverse price moves trigger margin requirements and prevent speculators from allocating additional capital to illiquid securities. In some situations, speculators are forced to reduce their holdings of illiquid securities (a flight to liquidity).

In funding-constrained environments, all assets become sensitive to changes in the availability of funding, since borrowing is an imperfect substitute for the liquidation of assets. Less liquid assets, however, are more sensitive to changes in available funds due to their larger margin requirements.[4] Therefore, illiquid securities experience larger price swings relative to liquid securities as speculator funding conditions fluctuate. As funding conditions become more constrained and speculators are forced to exit positions in illiquid assets and hold more liquid assets, the illiquidity premium increases. And conversely, the illiquidity premium contracts as funding conditions improve, and speculators have more capital available that can be directed to profitable investment in illiquid securities. The evidence in our paper is generally consistent with the theories of Amihud and Mendelson (1986), Acharya and Pedersen (2005), and Brunnermeier and Pedersen (2009).

From the empirical literature, Fujimoto (2004) and Chordia, Sarkar, and Subrahmanyam (2005) suggest that relatively tight (relaxed) monetary policy is associated with less (more) aggregate liquidity. Furthermore, several studies report an association between monetary conditions and aggregate market returns (see, as examples, Jensen, Mercer, and Johnson, 1996; Patelis, 1997; Thorbecke, 1997; Perez-Quiros and Timmermann, 2000). These studies are indirectly linked to our research and serve to motivate additional analysis into the liquidity pricing implications associated with monetary conditions.

The paper that perhaps is most closely related to our analysis is Amihud (2002), which looks at the effects of market liquidity on the returns of individual liquidity-sorted portfolios. Amihud finds that changing market liquidity has a greater effect on the returns of more illiquid portfolios. He decomposes market liquidity into an expected component and an unexpected component. He finds that the largest effect on returns comes from the unexpected component of market liquidity. Amihud, however, does not explicitly examine the illiquidity premium, and further, he does not relate monetary conditions to market liquidity or liquidity pricing. By addressing these issues, we are able to answer several important questions.

First, we find that monetary conditions have a statistically significant relation to next period's unexpected component of market liquidity, which is consistent with increased speculator funding being a catalyst for liquidity. As such, we are able to add empirical substance to the event of unexpected liquidity by showing that it is related to expansive monetary conditions. Thus, monetary conditions represent a measure that is available to market participants and is an instrumental variable for unexpected liquidity.

Second, by examining temporal variation in the returns of illiquid stocks, relative to liquid stocks, we determine the degree to which speculators allocate funds back and forth between liquid and illiquid stocks. Furthermore, we investigate the timing of flights to liquidity by relating the variation in the return difference (between illiquid and liquid stocks) to specific monetary policy periods. As such, we are able to identify economic states in which liquidity improves and investors increase their desired holdings of illiquid stocks (following expansive monetary policy shifts) and states in which an improvement in stock liquidity is of relatively little value to investors (following restrictive monetary policy shifts).

Third, before expansive monetary policy shifts, we detect deterioration in market liquidity and an increase in the premium demanded for holding illiquid stocks. The increase in the premium is consistent with speculators being forced to allocate funds from illiquid to liquid stocks, a flight to liquidity. The consequence of such a flight to liquidity is to expand the premium that market participants require for holding illiquid stocks. In the

[3] In the financial markets, institutions that fill the role of speculator are hedge funds, banks, and market makers.

[4] Alternatively, less liquid stocks can be funding-constrained for institutional reasons. For example, cash conversion needs of mutual fund investors create a funding constraint requiring mutual funds to hold stocks that are more liquid. See Falkenstein (1996) for evidence on mutual fund holdings.

weeks following expansive policy shifts, we find evidence that market liquidity improves and the illiquidity premium contracts, suggesting an increase in the ability of speculators to hold illiquid stocks. This is consistent with Brunnermeier and Pedersen's (2009) model, which indicates that deteriorating funding conditions force speculators to hold stocks that are more liquid. A subsequent improvement in funding conditions enables speculators to increase their desired holdings of illiquid stocks, which reduces the illiquidity premium.

Fourth, we present evidence suggesting that the price of liquidity is relatively invariant to fluctuations in aggregate liquidity around periods when the Fed shifts to a restrictive policy stance. This finding is consistent with Brunnermeier and Pedersen's (2009) contention that stock liquidity has a minimal effect on stock prices when capital is unconstrained. To avoid spurring a liquidity crisis, a Fed policy shift to a restrictive stance is only feasible when the liquidity concerns of market participants are relatively subdued, i.e., when capital is relatively unconstrained. Thus, our evidence is consistent with the view that restrictive monetary conditions coincide with periods of relatively unconstrained capital and little concern about stock liquidity.

Finally, in addition to supporting Brunnermeier and Pedersen's (2009) model, our results are also generally consistent with the models of Amihud and Mendelson (1986) and Acharya and Pedersen (2005). A prediction central to these models is that expected stock returns are decreasing in the level of stock liquidity.[5] It follows that expected returns will decline the most for stocks with the largest improvement in liquidity due to a greater reduction in illiquidity costs (see Proposition 2 of Acharya and Pedersen). While liquidity improves for the entire market during monetary expansions, we find it improves the most for illiquid stocks. Illiquid stocks (relative to liquid stocks) also experience the largest decline in expected returns during monetary expansions, as seen by their greater increase in price. We confirm that the return difference between illiquid and liquid stocks is abnormally large subsequent to an expansive monetary policy shift. According to Acharya and Pedersen, Proposition 3, with improving funding conditions, illiquid stocks, relative to liquid stocks, experience a greater increase in liquidity, and a greater reduction in the returns required by investors. Thus, illiquid stock prices react more favorably than liquid stocks to the improved conditions, which results in a wider spread in the measured return differential between the two.

3. Data and variables

3.1. Data

We evaluate monthly stock returns during the period from September 1954 through December 2006. The sample consists of all stocks in the Center for Research in Security Prices (CRSP) Center for Research in Security Prices (CRSP) database with a valid price for the last trading day of the previous year. Additionally, we require that firms have no change in listing venue or large stock splits within the last 3 months of the previous year. In computing portfolio returns, delisting returns from CRSP are used to mitigate survivorship bias issues (see Shumway, 1997; CRSP, 2001). Time-period restrictions on the sample are dictated by the availability of data needed to compute the monetary conditions measures.[6] We consider monthly returns for a sample that consists of 170,787 firm-years. Three alternative liquidity measures and two alternative monetary conditions measures are used.

3.2. Liquidity measures

Amihud, Mendelson, and Pedersen (2005) note that liquidity measures gauge liquidity with an error "because (i) a single measure cannot capture all the different dimensions of liquidity, (ii) the empirically derived measure is a noisy estimate of the true parameter, and (iii) the use of low-frequency data to create the estimates increases the measurement noise." To address the problems inherent in relying on a single measure of liquidity, we use three alternative measures.[7] Two of the measures are designed as price impact measures, *ILLIQ* and *Amivest*, while the third measures the effective cost of trading. Each of the three measures has been used recently and has significant support. The measures are derived from daily data, but are averaged to produce annual measures for each firm.

The first of the three measures, *ILLIQ*, was developed by Amihud (2002) and is closely related to the price impact coefficient, which was developed by Kyle (1985).[8] It is calculated for each stock i in every year Y as follows:

$$ILLIQ_{iY} = \frac{1}{t}\sum_{t}\frac{1{,}000{,}000 \times |return_t|}{price_t \times volume_t},$$

where t is a positive-volume trading day within the relevant year. Since the measure is undefined when dollar volume is zero, the measure is calculated over all positive-volume days. Acharya and Pedersen (2005) find that securities with high values of *ILLIQ* also have liquidity that comoves with market liquidity, returns that comove with market liquidity, and firm liquidity that comoves with market returns. Thus, firms with high values of *ILLIQ* also exhibit high illiquidity risk. Hasbrouck (2002) considers several of the most prominent measures of illiquidity and concludes that *ILLIQ* "appears to be the best" of the alternative proxies.

The second measure is the Amivest liquidity ratio (*Amivest*), which is calculated for each stock i in every

[5] See Proposition 2 of Amihud and Mendelson (1986) and Proposition 1 of Acharya and Pedersen (2005).

[6] The effective federal funds rate data are not available until July 1954. The change in the rate from July 1954 to August 1954 is matched with stock returns in September 1954.

[7] We thank Joel Hasbrouck for providing the annual data for liquidity measures.

[8] Hasbrouck (2009) finds a cross-stock Spearman correlation of 0.82 between the price impact coefficient and *ILLIQ*.

Table 1
Descriptive statistics of liquidity measures: 1953–2005.

This table shows descriptive statistics for the three liquidity measures used throughout the paper. Annual liquidity measures use the 1953–2005 CRSP daily data set, restricted to ordinary shares that had a valid price for the last trading day of the year and had no change of listing venue or large splits within the last 3 months of the year. The statistics are calculated by pooling across all 170,787 firm-years.

The Amihud illiquidity measure, *ILLIQ*, is calculated for each stock i in every year Y as follows:

$$ILLIQ_{iY} = \frac{1}{t}\sum_{t}\frac{1{,}000{,}000 \times |return_t|}{price_t \times volume_t},$$

where t is a positive-volume trading day within the year the measure is calculated.

The Amivest liquidity ratio is calculated for each stock i in every year Y as follows:

$$Amivest_{iY} = \frac{1}{t}\sum_{t}\frac{0.000001 \times price_t \times volume_t}{|return_t|},$$

where t is a trading day with a non-zero return within the year the measure is calculated.

The Gibbs estimate of effective cost is the annual Bayesian estimate of c for each stock on positive-volume trading days from the following regression model:

$$\Delta p_t = c\Delta q_t + \beta r_{mt} + u_t,$$

where r_{mt} is the excess market return on day t and p_t is the log trade price on day t. The q_t are direction indicators, which take values of "+1" for a buy or "−1" for a sale. u_t is a disturbance term that is uncorrelated with q_t. Additional details on the Gibbs estimate of effective cost can be found in Hasbrouck (2009).

	Correlation				Std. dev.
Liquidity measure	*ILLIQ*	*Amivest*	*Gibbs*	Mean	
Amihud illiquidity measure (*ILLIQ*)	1.00			6.27	40.42
Amivest liquidity ratio	−0.95	1.00		40,204	7.96 million
Gibbs estimate of effective cost	0.74	−0.66	1.00	0.01	0.02

year Y as follows:

$$Amivest_{iY} = \frac{1}{t}\sum_{t}\frac{0.000001 \times price_t \times volume_t}{|return_t|},$$

where t is a trading day with a non-zero return within year Y. Since zero-return days are undefined, they are eliminated from the calculation. This measure has been widely used (see, as examples, Cooper, Groth, and Avera, 1985; Amihud, Mendelson, and Lauterback, 1997; Berkman and Eleswarapu, 1998). It should be noted that *ILLIQ* and *Amivest* are derived from the same three values, and thus, are closely related. From Table 1, the pooled correlation coefficient for the two measures is −0.95. Differences in the two measures derive from the different states in which the measures are undefined. The price impact measures are intended to capture market depth for a particular stock. Stocks that can absorb large quantities of trade without significant price moves are liquid stocks; whereas, illiquid stocks experience noticeable price changes with less trading volume.[9]

The final measure is the Gibbs estimate of effective cost (*Gibbs*), which represents an estimate of the effective cost of trading. Starting with the Roll (1985) model, Hasbrouck (2009) performs Gibbs sampler estimation from positive-volume days to develop *Gibbs*. The Gibbs sampler is a three-step iterative process that relies on a Bayesian regression to produce an estimate of liquidity. The Gibbs estimate of effective cost is the annual Bayesian estimate of c for each stock from the following regression model:

$$\Delta p_t = c\Delta q_t + \beta r_{mt} + u_t,$$

where r_{mt} is the excess market return on day t, p_t is the log trade price on day t, and q_t is a direction indicator, which takes a value of +1 for a buy and −1 for a sale. u_t is a disturbance term that is uncorrelated with q_t. Hasbrouck finds that *Gibbs* is highly correlated with the effective spread estimated from transaction and quote (TAQ) data. Using TAQ and Dash −5 data, Goyenko, Holden, and Trzcinka (2009) evaluate 12 alternative measures of effective spread and conclude that *Gibbs* is the best overall measure of annual effective spread.[10]

The correlations reported in Table 1 are, in all respects, consistent with expectations. Since the variables are alternative liquidity measures, a high correlation between the variables is expected. The correlations indicate that *Gibbs* is strongly related to both *ILLIQ* and *Amivest*, ρ=0.74 and −0.66, respectively. These correlations are considerably less than 1.0, which supports the uniqueness of *Gibbs*. *Gibbs* is designed to indicate a different dimension of liquidity, effective cost of trading; whereas, *ILLIQ* and *Amivest* proxy for the price impact dimension. The mean and standard deviation indicate that *Gibbs* exhibits a far

[9] Amihud (2002) also shows that *ILLIQ* is correlated with a fixed-cost component of trading costs related to the bid-ask spread, in addition to being correlated with the variable-cost component related to market depth.

[10] Another useful feature of *Gibbs*, compared to the other liquidity measures, is that variation across firms cannot be attributed merely to high average trading volume or average daily returns that are unusually large.

tighter distribution than the other two measures; its standard deviation is only two times its mean.

3.3. Monetary policy measures

We use two alternative measures to identify shifts in Federal Reserve monetary policy. The first measure is based on changes in the federal funds rate, which has been widely used to identify adjustments in Fed stringency in the short-term market. The second measure is based on changes in the Fed discount rate and has been used previously to identify fundamental shifts in overall Fed monetary policy. Details regarding the two measures are provided below, while the appendix reports data that validate the measures as monetary conditions proxies.

The federal funds rate has a long history as an indicator of the stringency of Fed monetary policy. Bernanke and Blinder (1992) present results from variance decompositions that support the federal funds rate as the dominant variable in explaining variation in several measures of economic activity. The authors suggest that the sensitivity of the federal funds rate to shocks in the supply of bank reserves makes it a good indicator of monetary policy actions. Also, the federal funds rate has been used frequently as a monetary policy proxy in empirical analyses of stock returns (see, for example, Thorbecke and Alami, 1994; Patelis, 1997; Thorbecke, 1997; Perez-Quiros and Timmermann, 2000).

The second measure of monetary conditions is advocated by several researchers (see, for example, Jensen, Mercer, and Johnson, 1996; Booth and Booth, 1997; Fujimoto, 2004). The authors identify shifts in the Fed's overall monetary policy stance using changes in the Fed discount rate to classify policy periods as either expansive or restrictive. Jensen, Mercer, and Johnson (1996) confirm the efficacy of the measure by showing that both monetary aggregates and reserve aggregates differ significantly between the expansive and restrictive policy periods identified with the approach.[11] The authors suggest that the measure identifies turning points in the Fed's broad policy stance, not minor changes in the *degree* of monetary stringency.

Since the focus of the analysis is identifying shifts in Fed policy, both monetary policy variables are measured as binary variables. Further, the measures are employed both individually and in concert with one another. Patelis (1997) argues that shifts in the stringency of monetary policy should affect the market differently depending on whether the Fed is maintaining an expansive or a restrictive policy stance. Anecdotal evidence clearly supports this contention as the Fed frequently modifies its "policy bias" or "policy tilt" without changing its fundamental policy stance.[12]

The variable *Stringency* is considered "expansive" for a given month t whenever the effective federal funds rate decreases from month $t-1$ to month t. When the federal funds rate increases from month $t-1$ to t, *Stringency* is labeled "restrictive" for month t. When the federal funds rate does not change, *Stringency* maintains its value from the prior month.[13] In our analysis, *Stringency* is used to represent changes in the degree of monetary strictness. The variable *Stance* is used to identify fundamental shifts in the Fed's general policy stance, and therefore, it changes only with a directional change in the Fed discount rate (e.g., the first rate decrease in a series initiates an expansive stance). *Stance* is "expansive" for a given month t if the previous change in the Fed discount rate was a decrease, while *Stance* is "restrictive" for all months that follow an increase in the discount rate.

While directional changes in the federal funds rate are a fairly common occurrence, directional changes in the Fed discount rate occur infrequently. Thus, *Stringency* exhibits considerably more time-series variation than *Stance*, consistent with *Stringency* identifying finer shifts in policy strictness. Since the measures identify a shift in policy, no-change months maintain the existing policy. To avoid look-ahead bias, stock returns are measured subsequent to identified shifts in Fed policy.

Table 2 reports frequency data for the two monetary conditions measures. The data in Panel A consider the two measures independently and indicate that both measures (*Stringency* and *Stance*) divide the sample approximately evenly into expansive versus restrictive months. Panel B reports numbers that identify the intersection of the two measures. The prominent numbers on the diagonal indicate that, more often than not, the policy measures tend to reinforce one another. Of the 628 months, the two measures simultaneously identify expansive policy conditions in 182 months, while both are restrictive in 226 months. The significant number of observations in the off-diagonal, which represent non-reinforcing policy months, clearly identifies the uniqueness of the two indicators of monetary policy shifts. A little more than one-third of the time, the broad policy signaled by a discount rate change (*Stance*) is not reinforced by the policy strictness indicated by a federal funds rate change (*Stringency*). Such situations occur, for example, when the Fed keeps its broad policy intact, but alters the strictness of the existing policy.

4. Results

4.1. Unconditional return difference between illiquid and liquid stocks

For comparison with prior research, we begin our examination of the pricing implications of illiquidity by presenting portfolio returns across liquidity quintiles without regard to monetary conditions. In Table 3, we form quintile portfolios at the end of December of

[11] Following Jensen, Mercer, and Johnson (1996), we identify a shift in the Fed's monetary stance based on an announced change in the discount rate by any Federal Reserve Bank. The "announcement date" represents the Fed's signal to investors of its intention to change policy. For our sample of events, the announcement date differs from the effective date reported on the Federal Reserve Web site in nine cases. All announcement dates are confirmed using the *Wall Street Journal*.

[12] See Bernanke, Reinhart, and Sack (2004) for a discussion of Fed policy shifts and Fed communications.

[13] We observe 24 months for which the effective federal funds rate does not change.

Table 2
Frequency of alternative monetary conditions.

This table shows the frequency (in months) of alternative monetary states during the sample period. *Stringency* is derived from the monthly effective federal funds rate reported in the *Federal Reserve Statistical Release H.15*, *Selected Interest Rates*. An increase in the rate from the prior month is labeled a "Restrictive" month and a decrease is labeled an "Expansive" month. *Stance* is determined based on announced changes in the Federal Reserve discount rate. Each month *t* that follows an announced discount rate increase (decrease) is labeled Restrictive (Expansive). For each measure, whenever there is no change from one month to the next, the month maintains its prior label. Months are labeled expansive or restrictive over the entire period from September 1954 through December 2006.

	Number of months in alternative monetary state		
Monetary state measure	Expansive	Restrictive	All
Panel A: Months across monetary conditions: Measures separated			
Stringency	273	355	628
Stance	311	317	628

		Number of months in alternative monetary state *Stringency*	
	Stance	Expansive	Restrictive
Panel B: Months across monetary conditions: Measures intersected			
	Expansive	182	129
	Restrictive	91	226
			All=628

Table 3
Monthly returns on liquidity-ranked portfolios: September 1954–December 2006.

This table shows equal-weighted, average monthly returns (in percentage format) for quintile portfolios formed based on the three liquidity measures described in Table 1. Quintile portfolio ranks are determined by the value of the liquidity measure in the year prior to the year in which returns are measured. The "Illiquid–Liquid" portfolio is a portfolio that takes a long position in the quintile of stocks with the lowest level of liquidity and a short position in the quintile of stocks with the highest liquidity. Newey–West *t*-statistics for long–short portfolios are reported in italics and underneath the monthly average returns. The bandwidth parameter for Newey–West *t*-statistics is equal to one plus the number of autocorrelated lags that persist in significance at the 5% level.

	Mean monthly portfolio return (in percent)					
	Liquidity portfolio					
Liquidity measure	Illiquid	2	3	4	Liquid	Illiquid–Liquid
Amihud illiquidity measure (*ILLIQ*)	1.88	1.32	1.13	1.02	0.98	0.91
						t=4.18
Amivest liquidity ratio	1.88	1.33	1.11	1.03	0.98	0.90
						t=4.26
Gibbs estimate of effective cost	1.77	1.29	1.11	1.07	1.11	0.66
						t=2.82

each year t based on illiquidity as measured over year t. Stocks are held in portfolios over year $t+1$ until the end of December of year $t+1$ when portfolios are rebalanced. Throughout the paper we report results with equal-weighted portfolios.[14]

Consistent with prior literature, and as predicted in the models of Amihud and Mendelson (1986) and Acharya and Pedersen (2005), we find that returns are increasing in stock illiquidity. In Table 3, we observe a decrease in returns when moving from the low liquidity quintile (Illiquid) to the high liquidity quintile (Liquid). The final column of the table reports returns for a zero-investment portfolio that is long the Illiquid portfolio and short the Liquid portfolio. For each of the three illiquidity measures, the zero-investment portfolio earns returns that are both economically and statistically significant. Thus, the stock return premium for illiquidity measured by numerous other researchers is

[14] As a robustness check, we also perform our empirical analysis with value-weighted returns and find similar results. An exception is that when the Gibbs measure is used with value-weighted returns, the return difference between illiquid and liquid stocks is insignificant. The return difference with Gibbs, however, is still shown to be large and significant during expansive monetary periods and close to zero otherwise.

replicated in our sample.[15] In particular, the 91 (90) basis-point return difference between illiquid and liquid stocks with *ILLIQ* (*Amivest*) is comparable to the 106 basis points per month reported by Acharya and Pedersen (2005) as the sum of their illiquidity risk premiums. The return difference of 66 basis points a month estimated using *Gibbs* is comparable to the value of about 68 basis points per month estimated by Amihud and Mendelson (1986) using bid-ask spreads (see their Table 2).

4.2. Aggregate illiquidity and monetary conditions

The measures reported in Table 3 confirm the unconditional illiquidity premium shown by previous researchers. Our objective is to determine whether this widely acknowledged premium varies systematically with changes in monetary conditions. Closely related to this issue, prior empirical literature finds evidence of a link between monetary conditions and *aggregate* illiquidity (Fujimoto, 2004; Chordia, Sarkar, and Subrahmanyam, 2005). Furthermore, theory suggests that changes in aggregate illiquidity impact returns and the illiquidity premium (Acharya and Pedersen, 2005; Brunnermeier and Pedersen, 2009). Since these studies have important implications for our research, in this section, we sidestep the focus of this paper to investigate the relation between aggregate illiquidity and monetary conditions.

We use innovations in the market-wide version of *ILLIQ* as an aggregate measure of illiquidity, similar to the measure adopted by Pastor and Stambaugh (2003).[16] The advantages of using this measure include its ease of computation, its lengthy time-series availability, its precedence in the literature, and its similarity to two of the liquidity measures we use for portfolio formation. Illiquidity for each stock i in month t is calculated as follows:

$$ILLIQ_{i,t} = \frac{1}{d}\sum_{d}\frac{1{,}000{,}000 \times |return_d|}{price_d \times volume_d},$$

where d is a positive-volume trading day within the month the measure is calculated. This measure can be interpreted as the monthly version of annual *ILLIQ* used throughout the paper in forming illiquidity-based portfolios. The aggregate value of illiquidity is calculated as follows:

$$AILLIQ_t = \frac{1}{N_t}\sum_{i=1}^{N} ILLIQ_{i,t},$$

where N_t includes all firms with an observation for *ILLIQ* in month t except for the highest and the lowest 1% of $ILLIQ_{i,t}$. Monthly changes in aggregate illiquidity are calculated for each month t as follows:

$$\Delta AILLIQ_t = \frac{m_{t-1}}{m_1}(AILLIQ_t - AILLIQ_{t-1}).$$

where m_{t-1} is the total market value at the beginning of month $t-1$ for all firms with an observation for $ILLIQ_{i,t}$ in month t. m_1 is the total market value at the beginning of September 1954 for all firms with an observation for $ILLIQ_{i,t}$ in September 1954. The change in aggregate illiquidity is scaled since the price impact of the same dollar volume in trade declines over time. We regress the monthly change in aggregate illiquidity on its lag and the scaled lagged value of aggregate illiquidity as follows:

$$\Delta AILLIQ_t = \alpha + \beta\,\Delta AILLIQ_{t-1} + \lambda\left(\frac{m_{t-1}}{m_1}\right)AILLIQ_{t-1} + \varepsilon_t.$$

Aggregate illiquidity innovations are the fitted values of the regression residual, $\hat{\varepsilon}_t$. The aggregate illiquidity innovation provides a dynamic measure of market liquidity conditions. Thus, a positive value of the aggregate illiquidity innovation, $\hat{\varepsilon}_t$, indicates that the market becomes more illiquid (less liquid) from one month to the next.

Table 4 reports the average aggregate illiquidity innovation across monetary conditions. Monthly values of $\hat{\varepsilon}_t$ are matched with expansive or restrictive monetary conditions based on the change in monetary conditions in month $t-1$. For the entire sample period, the average value of $\hat{\varepsilon}_t$ is -0.000 and is not significantly different from zero, which indicates that scaling, first-differencing, and measuring the innovation, successfully eliminates the trend of increasing aggregate liquidity.[17] From Table 4, innovations in aggregate illiquidity vary the most across monetary conditions as measured by *Stringency*. After expansive policy shifts in *Stringency*, the market becomes more liquid as evidenced by an average aggregate illiquidity innovation of -0.216 (t-statistic of -3.82). The market becomes less liquid after restrictive policy shifts as witnessed by $\hat{\varepsilon}_t$ of 0.168 (t-statistic of 3.06). Examining measures of monetary conditions in

[15] As noted by Amihud (2002), firm size is closely affiliated with firm liquidity, and thus, the size premium is related to the illiquidity premium. Our objective is not to decompose the illiquidity premium into component aspects, but rather to determine the extent to which the illiquidity premium documented by other researchers has time variation that can be explained by changes in monetary conditions. Based on Amihud's claim that firm size is a proxy for liquidity, we replicate our analysis using market capitalization as an alternative indicator of illiquidity. Our findings using firm size are consistent with those reported for the three illiquidity measures. These results are available upon request.

[16] The measure uses all NYSE and Amex stocks reported on CRSP; however, Nasdaq stocks are excluded since the inclusion of inter-dealer trades results in overstated volume (see Pastor and Stambaugh, 2003; Fujimoto, 2004). We use ordinary common shares (CRSP share codes 10 and 11) with a beginning-of-month price between \$5 and \$1,000 and at least 15 monthly return, price, and volume observations.

[17] The aggregate illiquidity innovation, $\hat{\varepsilon}_t$, uses the entire time series to estimate the residual and may be considered forward-looking. As an alternative, we used two additional measures based only on the change in aggregate illiquidity from one month to the next, $\Delta AILLIQ_t$. The two additional measures differ based on whether the difference in aggregate illiquidity is scaled or whether the aggregate value of illiquidity, $\Delta AILLIQ_t$, is scaled. We find that the results in Table 4 are not materially changed with either of these alternative measures.

concert reveals that market liquidity increases the most when both *Stringency* and *Stance* are expansive ($\hat{\varepsilon}_t$ is -0.279).[18]

While innovations in aggregate illiquidity associated with shifts in *Stringency* are significant, the findings in Table 4 indicate that the average innovations are not significant following broad policy shifts (expansive and restrictive *Stance* periods) as indicated by adjustments of -0.065 ($t=-1.17$) and 0.061 ($t=1.04$). The insignificant relationship is perhaps not terribly surprising because *Stance* identifies a fundamental shift in Fed policy, which is then compared to short-term innovations in aggregate illiquidity. Broad shifts in Fed policy would be expected to identify periods of generally different monetary policy, which may be more appropriately assessed by evaluating "cumulative" changes in aggregate illiquidity, rather than average short-term innovations in illiquidity.[19]

Fig. 1 shows the response of aggregate illiquidity innovations ($\hat{\varepsilon}_t$) to an impulse in monetary conditions and serves to illustrate and expound on the results in Table 4. The responses plotted in Fig. 1 are obtained by estimating the following vector autoregression (VAR) model:

$$Y_t = \delta + \sum_{j=1}^{K} \phi_j Y_{t-j} + u_t, \tag{1}$$

where Y is a vector that includes the aggregate illiquidity innovation, $\hat{\varepsilon}_t$, and a dummy variable that measures monetary conditions, *Monetary conditions*$_t$. δ is a vector of constants. When examining the response to an expansive (restrictive) impulse, *Monetary conditions*$_t$ is a dummy variable that is one in month t when monetary conditions are expansive (restrictive) and is zero when conditions are restrictive (expansive). When considering the monetary measures in combination (*Combined*), for an expansive (restrictive) impulse, *Monetary conditions*$_t$ is one in month t if conditions are expansive (restrictive) according to both *Stringency* and *Stance* and is zero otherwise. The lag length K for Eq. (1) is chosen according to the Akaike Information Criterion. The VAR is ordered as *Monetary conditions*$_t$, $\hat{\varepsilon}_t$. The impulse response functions allow us to examine the temporal relationship between policy shifts and aggregate illiquidity innovations.[20]

The impulse response functions in Fig. 1 confirm the association between monetary policy shifts and changes

Table 4
Aggregate illiquidity innovations and monetary conditions.

This table shows average monthly innovations in aggregate illiquidity across monetary states. The measure is derived from the monthly version of *ILLIQ* that is reported in Table 1.

The aggregate value of illiquidity (*AILLIQ*) is calculated as follows:

$$AILLIQ_t = \frac{1}{N_t}\sum_{i=1}^{N} ILLIQ_{i,t},$$

where N_t includes all firms with an observation for *ILLIQ* in month t except for the highest and lowest 1% of $ILLIQ_{i,t}$. Monthly changes in aggregate illiquidity are calculated for each month t as follows:

$$\Delta AILLIQ_t = \frac{m_{t-1}}{m_1}(AILLIQ_t - AILLIQ_{t-1}).$$

where m_{t-1} is the total market value at the beginning of month $t-1$ for all firms with an observation for $ILLIQ_{i,t}$ in month t. m_1 is the total market value at the beginning of September 1954 for all firms with an observation for $ILLIQ_{i,t}$ in September 1954.

We regress the monthly change in aggregate illiquidity on its lag and the scaled lagged value of aggregate illiquidity as follows:

$$\Delta AILLIQ_t = \alpha + \beta\,\Delta AILLIQ_{t-1} + \lambda\left(\frac{m_{t-1}}{m_1}\right)AILLIQ_{t-1} + \varepsilon_t.$$

Aggregate illiquidity innovations are the fitted values of the regression residual, $\hat{\varepsilon}_t$.

Monetary conditions, as labeled in month $t-1$, are assigned to a value of $\hat{\varepsilon}_t$ in month t. Measures of monetary conditions are detailed in Table 2. Newey–West t-statistics are reported in italics and underneath the monthly average. The bandwidth parameter for Newey–West t-statistics is equal to one plus the number of autocorrelated lags that persist in significance at the 5% level. Values are calculated over the period from October 1954 through December 2006.

Fed monetary policy	Aggregate illiquidity innovation		
	Stringency		
Stance	Expansive	Restrictive	All
Expansive	−0.279 *t=−4.23*	0.237 *t=2.96*	−0.065 *t=−1.17*
Restrictive	−0.078 *t=−0.70*	0.123 *t=1.70*	0.061 *t=1.04*
All	−0.216 *t=−3.82*	0.168 *t=3.06*	−0.000 *t=−0.00*

[18] Following Amihud (2002), we decompose aggregate illiquidity into expected and unexpected components and regress unexpected illiquidity on monetary conditions. The results indicate that the combined monetary measure has a significant negative relation (at the 1% level) with unexpected aggregate illiquidity, which provides further support for the view that monetary policy shifts contain important information about subsequent funding conditions.

[19] We perform two additional analyses to investigate more completely the relation between *Stance* and aggregate illiquidity. First, we consider cumulative changes in aggregate illiquidity following shifts in *Stance*. The cumulative change in aggregate illiquidity in the 12 months following an expansive shift in *Stance* is −1.66 (significant at the 1% level) and is 1.36 (insignificant) following a restrictive shift. Thus, cumulative aggregate illiquidity exhibits a significant pattern associated with *Stance*. Second, we investigate the interdependence of *Stance* and *Stringency* by evaluating the relation between *Stringency* and innovations in aggregate illiquidity across *Stance* periods. Specifically, a variance decomposition reveals that *Stringency* explains virtually *none* of the variation in aggregate illiquidity innovations during restrictive *Stance* periods (0.3%) but has substantial explanatory power during expansive *Stance* periods (16.6%). Thus, *Stance* greatly matters for aggregate illiquidity innovations, as the explanatory strength of *Stringency* is highly conditional upon *Stance*. Overall, the two additional analyses indicate that *Stance* has important ramifications for aggregate illiquidity, which are masked by averaging short-term innovations in illiquidity over entire *Stance* periods, as is done in Table 4.

[20] When the VAR ordering is reversed, the results are not materially changed.

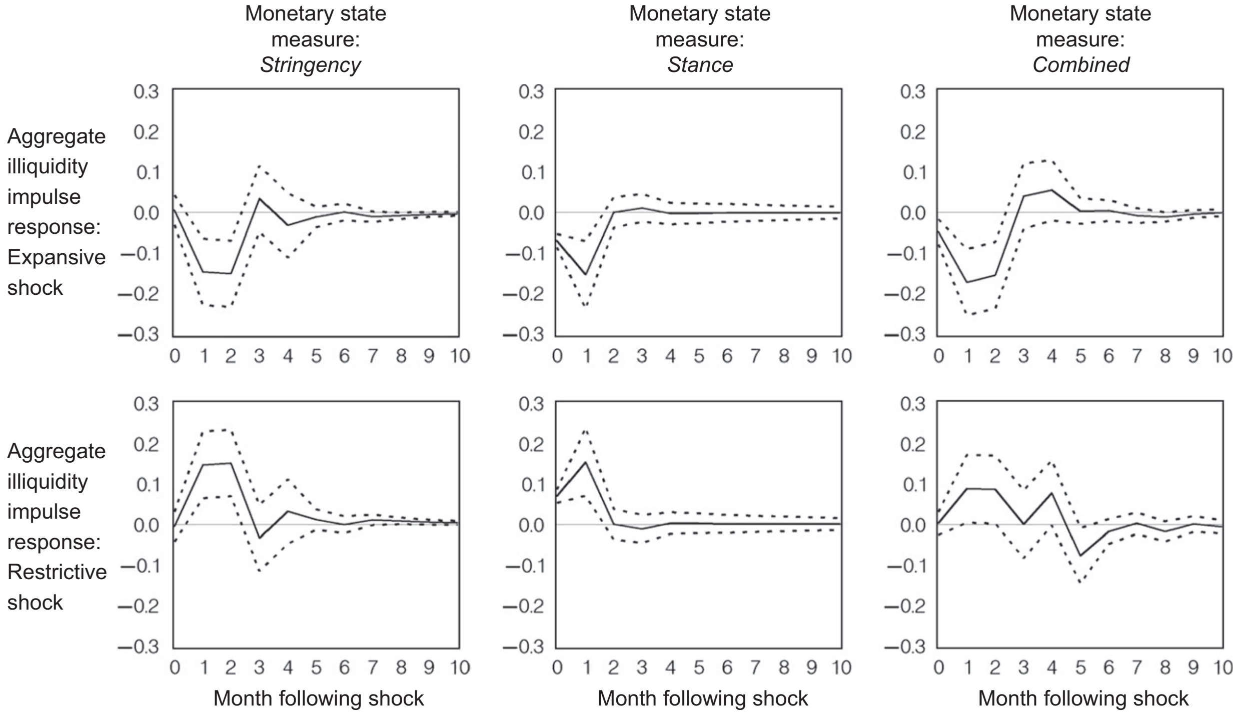

Fig. 1. Aggregate illiquidity impulse response functions. This figure shows the orthogonalized impulse response functions for aggregate illiquidity innovations, $\hat{\varepsilon}_t$, as defined in Table 4, to a Cholesky one-standard-deviation shock in monetary conditions. The first row of graphs shows the response of aggregate illiquidity to an expansive shock. The second row shows the response of aggregate illiquidity to a restrictive shock. The VAR lag length is chosen according to the Akaike Information Criterion, and the VAR is ordered as Monetary conditions, Aggregate illiquidity innovation. Dotted lines represent two-standard error bands. The sample period is from October 1954 through December 2006.

in aggregate illiquidity reported in Table 4. To allow for assessment of statistical significance, two standard error bands are reported for each plot in the figure. Shifts to an expansive policy correspond with an increase in liquidity as evidenced by a significant drop in aggregate illiquidity innovations, while a drop in liquidity accompanies a shift to a restrictive monetary policy. In contrast to the evidence in Table 4, the impulse responses identify significant innovations in aggregate illiquidity associated with both *Stringency* and *Stance*. The final plot in each row suggests that aggregate illiquidity innovations are more closely associated with *Combined* expansive policy shifts as opposed to *Combined* restrictive shifts.[21] The evidence in Fig. 1 is similar to the findings of Fujimoto (2004) and Chordia, Sarkar, and Subrahmanyam (2005) that a relaxation in monetary policy is associated with improved market liquidity, while tighter monetary policy corresponds with diminished aggregate liquidity. We detect a comparable, but somewhat stronger, association between monetary conditions and market liquidity than what was implied by the findings reported in Chordia et al.[22]

As a final analysis of the association between aggregate illiquidity and monetary conditions, we examine changes in illiquidity across the illiquidity quintiles. Our previous evidence indicates that liquidity increases (decreases) when monetary conditions are expansive (restrictive); however, the uniformity of the changes in liquidity across the quintiles is unknown. Table 5 separates stocks into the most illiquid quintile (Panel A) and the most liquid quintile (Panel B). Aggregate illiquidity innovations are

[21] When the VAR ordering is reversed, the response to *Combined* shifts has greater statistical significance in restrictive monetary periods than what is seen in Fig. 1. Otherwise, the impulse response functions look similar.

[22] It is difficult to directly compare our results to those in Chordia, Sarkar, and Subrahmanyam (2005) because the two analyses differ on several dimensions. A fundamental difference between the two is that Chordia et al. has a different research focus, which causes them to examine *unexpected* changes in monetary conditions, for *crisis* periods during the *1990s*, whereas we consider all changes in monetary conditions over a 50-year time period. Furthermore, Chordia et al. examines adjusted changes in aggregate illiquidity by removing any illiquidity changes associated with changes in economic conditions, whereas we evaluate unadjusted changes in aggregate illiquidity. Finally, the studies differ based on more technical aspects such as the monetary measures and liquidity measures used. In spite of these vast differences, both studies are in agreement regarding a fundamental finding; there is a significant relation between monetary conditions and market liquidity.

Table 5
Aggregate illiquidity innovations and monetary conditions: Most illiquid quintile and most liquid quintile.

This table shows average monthly innovations in aggregate illiquidity across monetary states separately for the quintile of the most illiquid stocks and the quintile of the most liquid stocks. The aggregate illiquidity innovation measure is detailed in Table 4. Panel C shows the difference in aggregate illiquidity innovations between the most illiquid and the most liquid quintile. Newey–West *t*-statistics are reported in italics and underneath the monthly average. The bandwidth parameter for Newey–West *t*-statistics is equal to one plus the number of autocorrelated lags that persist in significance at the 5% level. Values are calculated over the period from October 1954 through December 2006.

Panel: Monetary state	*A: Most illiquid quintile* Mean monthly illiquidity innovation *Stringency*			*B: Most liquid quintile* Mean monthly illiquidity innovation *Stringency*			*C: Illiquid minus liquid* Mean monthly illiquidity innovation *Stringency*		
Stance	Expansive	Restrictive	All	Expansive	Restrictive	All	Expansive	Restrictive	All
Expansive	−0.854	0.545	−0.275	−0.006	0.001	−0.003	−0.849	0.544	−0.272
	t=−4.52	*t*=2.29	*t*=−1.72	*t*=−3.46	*t*=0.42	*t*=−2.39	*t*=−4.51	*t*=2.29	*t*=−1.71
Restrictive	−0.072	0.418	0.268	0.000	0.004	0.003	−0.072	0.414	0.265
	t=−0.26	*t*=1.95	*t*=1.52	*t*=0.10	*t*=1.70	*t*=1.44	*t*=−0.26	*t*=1.95	*t*=1.51
All	−0.612	0.478	−0.000	−0.004	0.003	−0.000	−0.608	0.475	−0.000
	t=−3.96	*t*=2.95	*t*=−0.00	*t*=−2.10	*t*=1.71	*t*=−0.00	*t*=−3.95	*t*=2.95	*t*=−0.00

then related to expansive and restrictive monetary conditions for both quintile extremes. Panel C reports differences between the most and least liquid quintiles.

The results provide three clear findings. First, the most illiquid (least liquid) stocks experience a far greater change in illiquidity than the most liquid quintile, which experiences almost no change. Second, for the most illiquid quintile, following expansive (restrictive) policy shifts, illiquidity decreases (increases) significantly. Third, for the most illiquid quintile, the greatest decrease in illiquidity (greatest improvement in liquidity) occurs when both monetary policy indicators are expansive. Finally, from Panel B, there is little variation in the aggregate illiquidity innovations for the most liquid quintile of stocks.[23]

Overall, the findings in Table 5 are consistent with the contention that aggregate illiquidity decreases (liquidity improves) during expansive monetary periods and increases during restrictive periods. Furthermore, the results are consistent with Brunnermeier and Pedersen's (2009) contention that an improvement in funding conditions benefits illiquid stocks to a greater extent than liquid stocks.

The evidence reported above links monetary conditions with market liquidity, and helps to motivate an examination of the relation between the price of liquidity and monetary conditions. The rest of the analysis is devoted to exploring the temporal variation in the price of liquidity and its relation to changes in monetary conditions; this relation is the major focus of our analysis.

[23] Specifically, during expansive/expansive periods, a relatively slight improvement in liquidity occurs for the most liquid stocks as evidenced by the mean value of −0.006; however, this relatively small value is highly statistically significant ($t=-3.46$). Thus, during expansive monetary periods, liquidity is shown to improve for both the illiquid and liquid quintiles; however, the rate of change and volatility is substantially higher for the most illiquid quintile.

4.3. *Monetary conditions and returns to illiquid, relative to liquid, stocks*

Our results, thus far, support the claim that changing monetary conditions are associated with changes in investor funding conditions as in Brunnermeier and Pedersen (2009). Brunnermeier and Pedersen suggest that the return premium required for holding illiquid stocks decreases during periods associated with eased funding constraints because such periods increase the ability of speculators to allocate capital to illiquid stocks. Our findings are consistent with the claim that expansive monetary conditions correspond with eased funding constraints, while restrictive monetary conditions are associated with tighter funding conditions. Thus, the illiquidity premium should contract (expand) as monetary conditions become more expansive (restrictive). An implication is that during expansive monetary periods, liquidity conditions improve and the relative price and return for illiquid stocks increases. To test this hypothesis, we examine a portfolio that is long the quintile of the most illiquid securities and short the quintile of the most liquid securities (the zero-cost portfolio).

4.3.1. *Average return to the zero-cost portfolio across monetary conditions*

Table 6 reports the average return difference between the most illiquid and the most liquid quintile of stocks (the zero-cost portfolio) across expansive and restrictive monetary periods. The table is separated into three panels, one for each of the illiquidity measures, and each panel reports zero-cost portfolio returns associated with each of the two monetary conditions measures, *Stringency* and *Stance*, along with the combination of the two.

The values for the zero-cost portfolio reported in Table 6 are noteworthy for several reasons. First, the substantial size of the return difference, during periods

Table 6
Illiquid minus liquid portfolio returns across monetary conditions: September 1954 to December 2006.

This table shows zero-cost portfolio, equal-weighted average monthly returns (in percentage format) across different monetary conditions. Each return is for a portfolio long in the quintile of stocks with the lowest liquidity and short in the quintile of stocks with the highest liquidity. Returns are measured in month $t+1$ based on monetary conditions determined in month t. Liquidity and monetary conditions measures are detailed in Table 1 and Table 2, respectively. Newey–West t-statistics are reported in italics and underneath the monthly average returns. The bandwidth parameter for Newey–West t-statistics is equal to one plus the number of autocorrelated lags that persist in significance at the 5% level.

Panel: Monetary state	*A: Amihud illiquidity (ILLIQ)* Mean monthly return (in percent) *Stringency*			*B: Amivest liquidity ratio* Mean monthly return (in percent) *Stringency*			*C: Gibbs estimate of effective cost* Mean monthly return (in percent) *Stringency*		
Stance	Expansive	Restrictive	All	Expansive	Restrictive	All	Expansive	Restrictive	All
Expansive	2.31	0.27	1.49	2.31	0.32	1.51	2.02	0.01	1.20
	t=4.77	*t=0.74*	*t=4.43*	*t=4.82*	*t=0.89*	*t=4.54*	*t=4.16*	*t=0.01*	*t=3.54*
Restrictive	0.22	0.38	0.34	0.16	0.37	0.32	0.07	0.09	0.15
	t=0.34	*t=1.40*	*t=1.28*	*t=0.27*	*t=1.42*	*t=1.23*	*t=0.09*	*t=0.30*	*t=0.47*
All	1.60	0.34	0.91	1.58	0.35	0.90	1.37	0.05	0.66
	t=4.05	*t=1.55*	*t=4.18*	*t=4.08*	*t=1.66*	*t=4.26*	*t=3.35*	*t=0.21*	*t=2.82*

when both monetary policy indicators are expansive is unprecedented. Specifically, the average zero-cost portfolio return when *Stance* and *Stringency* are both expansive ranges from 2.31% for *ILLIQ* and *Amivest* (Panels A and B) to 2.02% for *Gibbs* (Panel C). Astonishingly, the portfolio return during periods when both policy measures are expansive is more than twice the size of the unconditional return, shown in the bottom right hand corner of each panel. When illiquidity is measured using *ILLIQ*, in Panel A, a difference of 1.40% in returns is observed between the conditional and unconditional returns to the zero-cost portfolio (2.31% versus 0.91%). Similar differences are reflected in the values reported in Panel B, 1.41% and Panel C, 1.36%. The extraordinarily large value for the zero-cost portfolio return during expansive–expansive periods is especially surprising given that this state represents a substantial proportion (approximately 29%) of the total sample period.

Second, in all cases, the average return difference between illiquid and liquid stocks is statistically insignificant when either of the monetary policy indicators is restrictive. When monetary conditions are restrictive, the return differences range from 0.01% to 0.38% across the illiquidity measures. Especially miniscule return differences are associated with *Gibbs* during restrictive monetary periods with the largest value registering only 0.09%.

Third, regardless of the monetary policy indicator used, the zero-cost portfolio return is shown to differ substantially across monetary conditions. For example, when evaluating the policy measures independently, the portfolio's return in Panel A is 1.49% (1.60%) when *Stance* (*Stringency*) is expansive. In contrast, the portfolio's return has a very low value of 0.34% when either *Stance* or *Stringency* is restrictive. Comparable values and patterns are reported in Panels B and C.

Fourth, the association between returns to the zero-cost portfolio and monetary conditions is extremely consistent across the alternative illiquidity and monetary measures. While *ILLIQ* and *Amivest* represent quite similar measures of illiquidity, *Gibbs* differs substantially from these two measures. As noted previously, *Gibbs* is designed to measure a different aspect of illiquidity than the other two illiquidity measures. Furthermore, the two monetary measures have very different designs and are also intended to measure different aspects of monetary conditions. Given these differences, the high degree of consistency across the values reported in Table 6 makes the results more noteworthy and helps to establish the robustness of the identified relationship.[24]

Overall, Table 6 shows evidence supporting a systematic relation between monetary conditions and the price of liquidity. An implication of this finding is that failure to control for changes in monetary conditions may result in a biased assessment of liquidity's relevance for asset pricing. Specifically, the findings suggest that an accurate assessment of the role that liquidity plays in asset pricing requires conditioning on shifts in monetary policy. Spiegel and Wang (2005), Hasbrouck (2009), and Vassalou, Chen, and Zhou (2006) dispute the relation between illiquidity, or illiquidity risk, and stock returns. Our results during restrictive monetary periods support this contention; however, during expansive periods we report evidence that refutes this claim.

4.3.2. Terminal wealth in different monetary conditions

Fig. 2 illustrates the striking difference in the growth of the zero-cost portfolio's value in expansive monetary conditions (the solid line) versus restrictive monetary

[24] The results in Table 6 are robust to adjustments made for outlier observations (unreported and available upon request). Winsorizing the most extreme 10% of observations results in a slight reduction in the magnitude of the zero-cost portfolio return; however, the portfolio's return remains statistically significant only in expansive periods. Furthermore, Wilcoxon and Kruskal–Wallis tests confirm that the portfolio's return is significant in expansive periods, but insignificant in restrictive periods. Thus, the observed relation between monetary conditions and the reported return difference between illiquid and liquid stocks is not driven by a few extreme events.

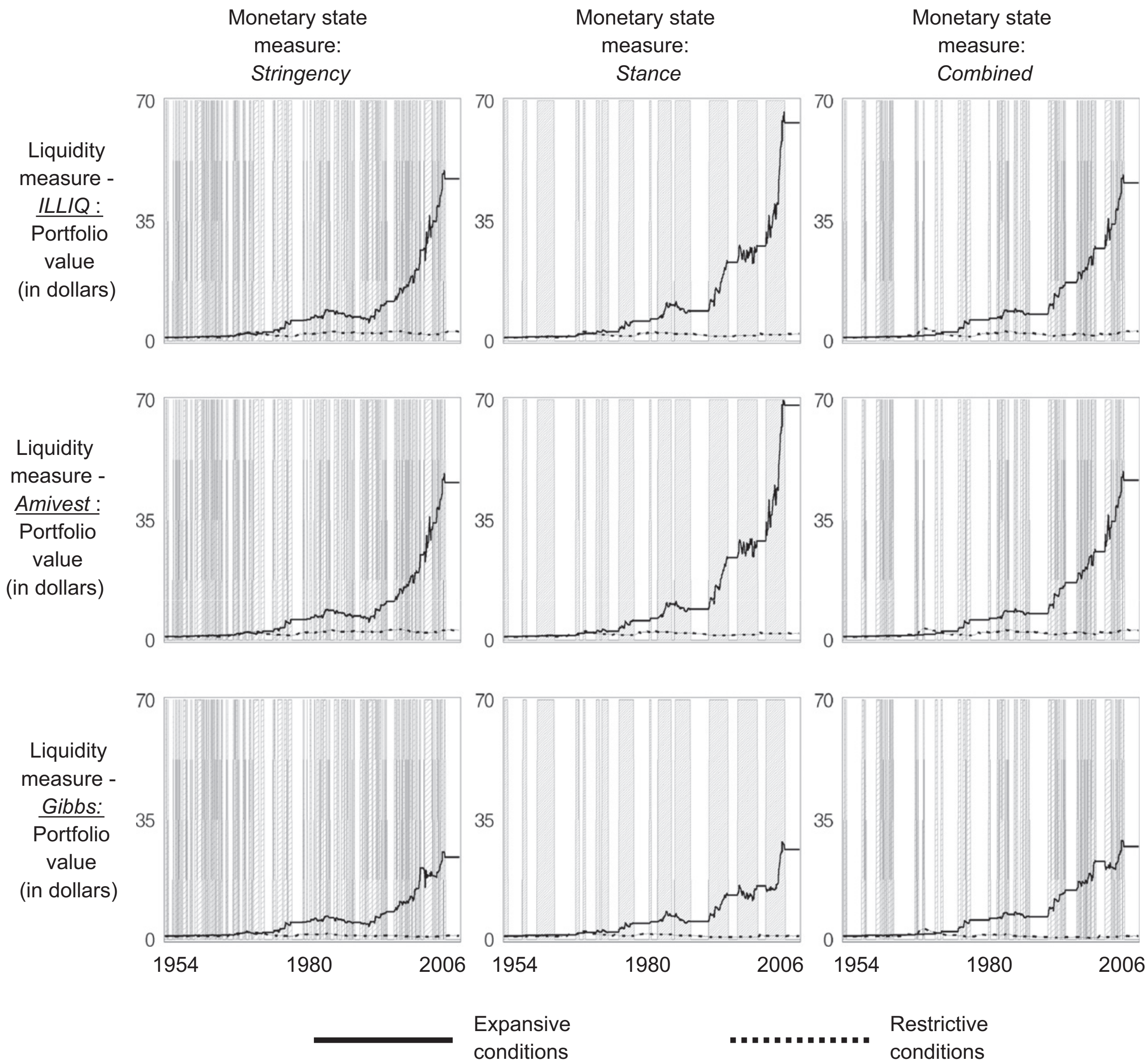

Fig. 2. Illiquid minus liquid portfolio growth of $1 in different monetary conditions. This figure shows the growth of $1 invested in the strategy long illiquid stocks and short liquid stocks in different monetary conditions over the 52-year study period (1954–2006). The solid line shows the dollar growth for investing in the long-short strategy during expansive states and not investing (zero returns) during restrictive periods. The dotted line shows the dollar growth for investing in the long-short strategy during restrictive states and not investing (zero returns) during expansive policy periods. The gray shaded bars represent expansive conditions. If monetary conditions are expansive for both *Stringency* and *Stance*, then *Combined* is labeled expansive; otherwise, monetary conditions are restrictive.

conditions (the dotted line). The solid line illustrates that the compounded portfolio return grows substantially during expansive policy periods. In stark contrast, the dotted line remains very close to $1, indicating nearly zero growth during restrictive periods. As shown in Table 2, *Stringency* and *Stance* are independently restrictive during 56.5% (355 months) and 50.5% (317 months), respectively, of the 628 month sample period. Considered together (*Combined*), one of the two measures is restrictive during 71% (91+129+226=446 months) of the sample period. Therefore, the lack of growth during restrictive periods is especially noteworthy. While the data reported in Table 6 indicate that the premium investors demand for holding illiquid stocks is related to monetary conditions, Fig. 2 confirms that the relationship exhibits a high degree of consistency over the 52-year study period.

4.3.3. Impulse response functions

To provide further information about the relation between the price of liquidity and monetary policy shifts, we estimate a vector autoregression model and report the resulting impulse responses. A VAR allows us to assess the ramifications that a shift in monetary policy has on the return to the zero-cost portfolio by considering

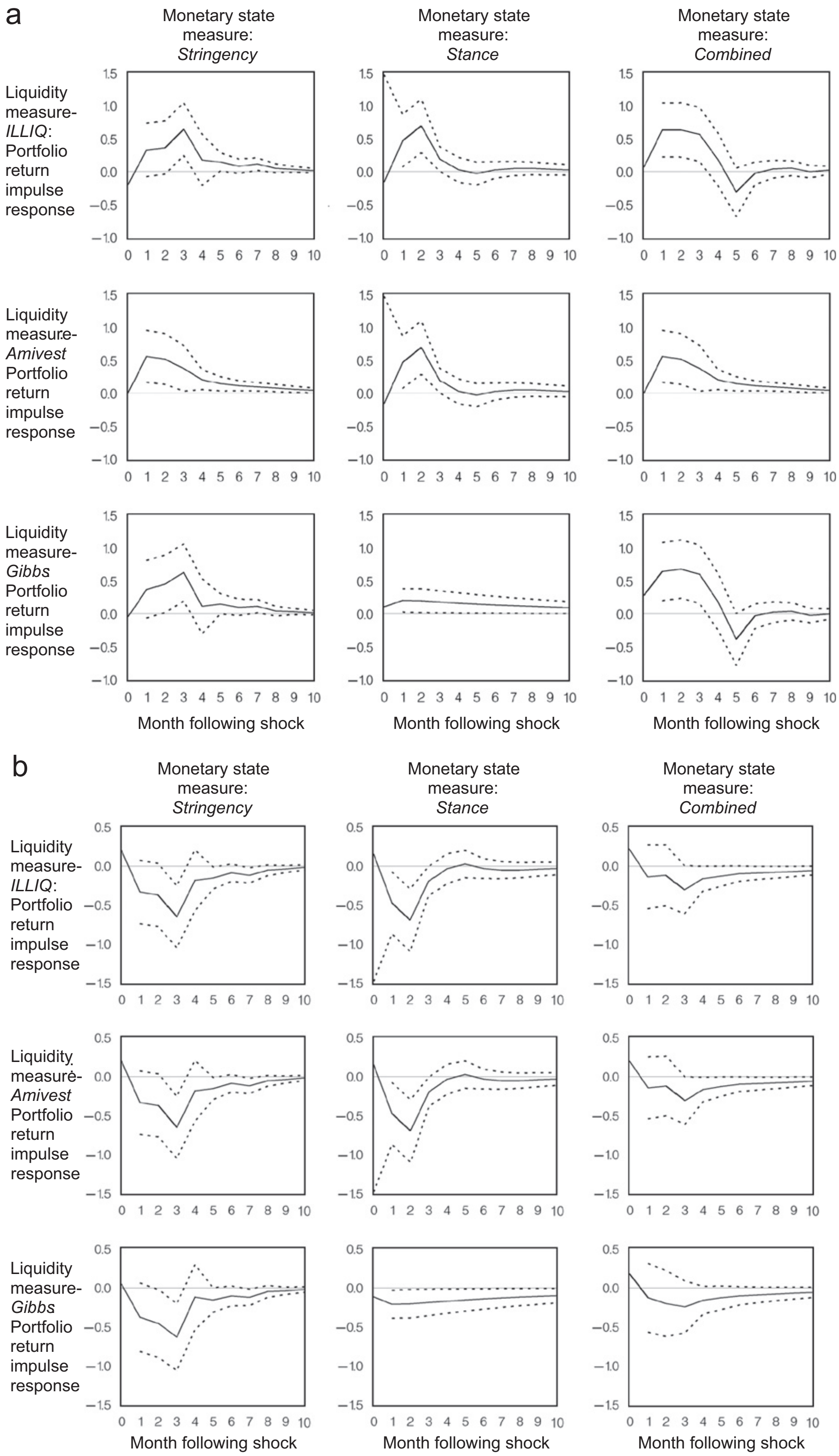

Fig. 3. (a) Illiquid minus liquid portfolio return impulse response function: Expansive shocks. This figure shows the orthogonalized impulse response function of the illiquid minus liquid portfolio return to a Cholesky one-standard-deviation expansive shock in monetary conditions. The VAR lag length is chosen according to the Akaike Information Criterion, and the VAR is ordered as Monetary conditions, Illiquid minus liquid portfolio. Dotted lines represent two-standard error bands. The sample period is from September 1954 through December 2006. (b) Illiquid minus liquid portfolio return impulse response function: Restrictive shocks. This figure shows the orthogonalized impulse response function of the illiquid minus liquid portfolio return to a Cholesky one-standard-deviation restrictive shock in monetary conditions. The VAR lag length is chosen according to the Akaike Information Criterion, and the VAR is ordered as Monetary conditions, Illiquid minus liquid portfolio. Dotted lines represent two-standard error bands. The sample period is from September 1954 through December 2006.

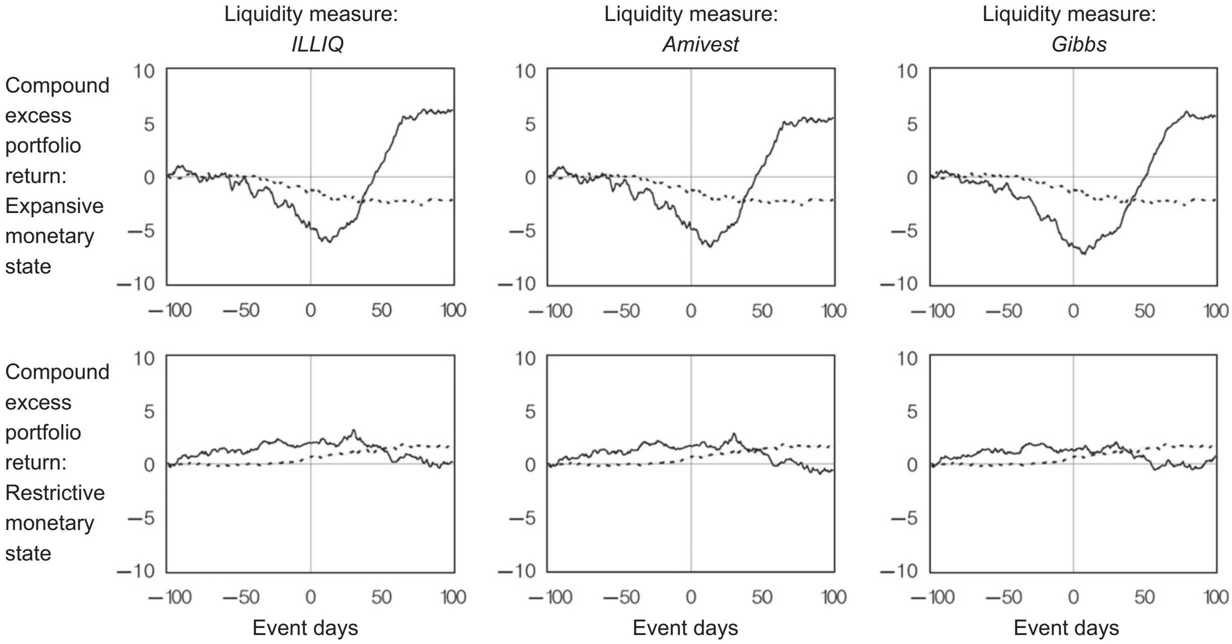

Fig. 4. Daily event study. This figure shows compound excess illiquid minus liquid portfolio returns around a directional change in the Federal Reserve discount rate (shift in *Stance*). The return is to a strategy that is long the quintile portfolio of illiquid stocks and short the quintile portfolio of liquid stocks. The solid line shows the event-time average of compounded daily returns in excess of the sample period mean for the long-short strategy. The dotted line shows the event-time average of cumulated changes in the federal funds rate. A monetary state is labeled as "Expansive" if the prior discount rate change was a decrease or "Restrictive" if the prior change was an increase. Numbers on the vertical axis are percentages. Numbers on the horizontal axis are event days. The sample period is from September 1954 through December 2006.

an alternative lag structure and by showing the timing of the response. We estimate the following vector autoregression model:

$$X_t = \delta + \sum_{j=1}^{K} \phi_j X_{t-j} + u_t, \qquad (2)$$

where X is a vector that includes zero-cost portfolio returns and a dummy variable that measures monetary conditions (*Monetary conditions$_t$*). δ is a vector of constants. *Monetary conditions$_t$* is defined for Figs. 3a and b in the same manner as Fig. 1. Fig. 3a shows the response to an expansive monetary policy impulse, while Fig. 3b illustrates the response to a restrictive impulse. The lag length K of Eq. (2) is chosen according to the Akaike Information Criterion.

Figs. 3a and b indicate that a monetary policy shift elicits a statistically significant response in the returns to the zero-cost portfolio. The most significant response, however, appears to occur at the second or third lag. Consistent with the results in Table 6, the zero-cost portfolio's return increases after expansive policy shocks and decreases after restrictive shocks. The response to a *Combined* expansive shock is shown to be more significant than the response to a *Combined* restrictive shock. This finding is consistent with the results in Table 6, which show that the return difference between illiquid and liquid stocks is especially large when *Stringency* and *Stance* both signal expansive policies. Furthermore, the strong association between the zero-cost portfolio return and monetary conditions during expansive monetary periods is consistent with the very large reduction in "aggregate" illiquidity during expansive–expansive periods (see Table 4), especially for the most illiquid stocks (see Table 5).[25]

4.4. Temporal analysis of the zero-cost portfolio around shifts in stance

The findings in Table 6 clearly establish the existence of a robust relation between monetary conditions and zero-cost portfolio returns; however, the exact nature of the temporal relation between monetary policy shifts and changes in the price of liquidity remains uncertain. To further address this uncertainty, we examine changes in the zero-cost portfolio's return for a 201-day event period around shifts in monetary policy.[26] Given that *Stringency* reflects a shift in the average "monthly" federal funds rate, relating the portfolio's return to *Stringency* using a "daily" event approach is not feasible. Therefore, in Fig. 4, we evaluate changes in the portfolio's return relative to only broad shifts in Fed policy (*Stance*).

Fig. 4 plots the compounded mean-adjusted returns for the zero-cost portfolio (solid line) measured for 100 days before and after an announced shift in *Stance*. The plot also includes the cumulative change in the federal funds rate (dotted line) to provide an indication of monetary

[25] The impulse response functions are nearly identical when the VAR ordering is reversed.

[26] We are grateful to an anonymous referee for suggesting this analysis.

policy *Stringency* during the period. The 201-day window offers a temporal view of sufficient duration to assess changes in liquidity pricing around broad monetary policy shifts. The plots in Fig. 4 indicate that the price of liquidity adjusts substantially around expansive policy shifts, but maintains a high degree of consistency around shifts to a restrictive policy. This finding is consistent with expectations as the Fed may be reluctant to shift to a restrictive policy during periods when the liquidity concerns of investors are elevated. In contrast, a shift to a more expansive policy would be expected to coincide with heightened liquidity concerns by investors.

There is a very pronounced pattern in the zero-cost portfolio's return around a shift to an expansive monetary policy (the top row of plots in Fig. 4). The plot clearly shows that the return difference between illiquid and liquid stocks is considerably below average in the period immediately around the policy shift; however, the return difference in the post-event period is substantially above average. Thus, it appears that the price of liquidity adjusts considerably in the days surrounding an expansive policy shift.

An examination of the compound excess returns to the zero-cost portfolio measured over the entire 201-day period reveals the following general pattern. The zero-cost portfolio's return for the majority of days in the 100-day period prior to a shift in policy *Stance* is substantially below average, with the smallest values occurring during the last 40 days. In general, the portfolio's return remains below average for approximately 10 days after the policy shift, before stabilizing. The portfolio's return is slightly above average for the next 20 days or so, and then expands considerably. In the period starting about 30 days after the policy shift, the portfolio's return is substantially above average and stays elevated for the next 30–40 days. From approximately day 60 forward, the zero-cost portfolio's return appears to stabilize and maintains a near-average value.[27]

The pattern observed in the zero-cost portfolio's return before and after an expansive monetary policy shift is consistent with the funding explanation offered by Brunnermeier and Pedersen (2009). In particular, prior to an expansive policy shift, liquidity concerns become heightened, and due to funding constraints, speculators are prevented from maintaining their desired holdings of illiquid stocks. The deterioration in funding conditions and liquidity causes market participants to increase the premium they require for holding illiquid stocks, and thus, the price and return of illiquid stocks is driven down relative to liquid stocks. Therefore, prior to an expansive policy shift, the relative decline in the price of illiquid stocks causes a reduction in the return to the zero-cost portfolio. It appears that, on average, a flight to liquidity continues for several days after the policy shift.

Eventually, it appears that an improvement in funding conditions, along with an attractive premium for bearing liquidity risk, encourages speculators to allocate more funds to illiquid stocks. In general, as speculators' access to capital becomes less constrained, the premium required for holding illiquid stocks diminishes. The increased investment in illiquid stocks causes their prices (returns) to increase and the returns to the zero-cost portfolio to expand.

The dotted line in the top row of plots in Fig. 4 indicates that the federal funds rate trends down during most of the extended event period. The rate appears to start falling approximately 30 days prior to the policy shift and continues falling until it stabilizes near the end of the window. This evidence is consistent with a gradual and consistent easing of monetary policy before and after a signaled shift in policy. Thus, it appears that the policy shift signals the Fed will continue to ease, rather than signaling that the Fed will begin to ease. In other words, the information signaled by the shift in *Stance* is that the easing in monetary *Stringency* will continue for an extended period. This evidence is consistent with the results reported by Thornton (1998b).

The bottom row of plots in Fig. 4 indicate that the price of liquidity adjusts relatively little around a shift to a restrictive monetary policy. The compound excess zero-cost portfolio returns remain consistently close to zero both before and after the policy shift. The plot, however, indicates that the values tend to be slightly higher than average before the pre-shift period, which is the end of an expansive monetary policy period. In contrast, the values tend to be somewhat below average in the post-shift period. Therefore, for the entire 201-day period, the compound return difference between illiquid and liquid stocks approximates the overall average return difference. The relative stability in the returns to the zero-cost portfolio around restrictive monetary periods supports the contention that the liquidity concerns of investors are relatively diminished at the time the Fed shifts to a restrictive policy *Stance*. This observation is consistent with expectations as the Fed would be expected to avoid a shift to a restrictive *Stance* during a period of elevated liquidity concerns by investors due to the negative ramifications such an action would have on the financial markets.

An examination of the federal funds rate around restrictive policy shifts indicates that the rate trends upward during the extended event period, but to a lesser degree than the trend depicted in the expansive policy plots. Furthermore, it appears that there is relatively little movement in the federal funds rate prior to the shift in policy.

It should be noted that the excess zero-cost portfolio returns plotted in Fig. 4 relate to *Stance* independently of *Stringency*. *Stringency* displays a strong pattern around shifts in *Stance*, which supports the expected positive correlation of the two measures. The plots, however, do not differentiate zero-cost portfolio returns between periods when *Stringency* reinforces *Stance* versus periods

[27] To provide an indication of the cumulative magnitude of the return difference between the most illiquid and liquid stocks, we calculate the compound excess return for the zero-cost portfolio over the 100-day post expansive-shift period, which is the period where the portfolio's return deviates the most from its average. For the three alternative illiquidity measures, the derived values range from 10.8% to 12.8% (t-statistics range from 3.98 to 4.59).

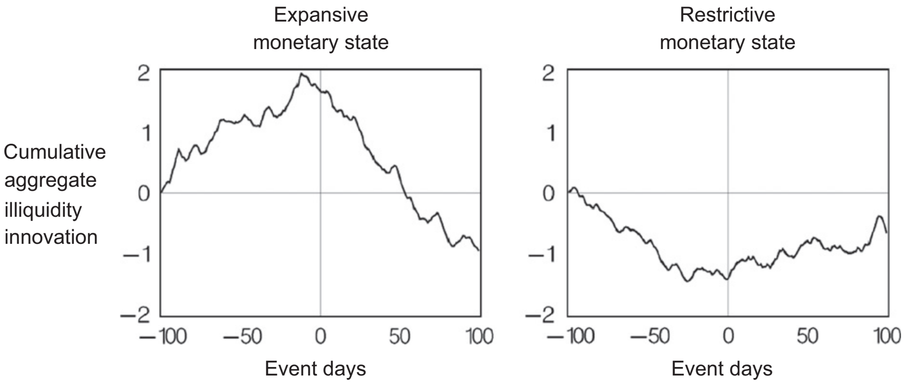

Fig. 5. Daily event study with aggregate illiquidity. This figure shows the event-time average of cumulative aggregate illiquidity innovations, $\hat{\varepsilon}_t$, around a directional change in the Federal Reserve discount rate (shift in *Stance*). The daily version of aggregate illiquidity innovations detailed in Table 4 is used. A monetary state is labeled as "Expansive" if the prior discount rate change was a decrease or "Restrictive" if the prior change was an increase. Numbers on the horizontal axis are event days, with day 0 representing the shift in *Stance*. The sample period is October 1954 through December 2006.

when *Stringency* contrasts with *Stance*. Therefore, given our prior evidence showing the relevance of *Stringency*, the plots in Fig. 4 should be viewed as a conservative and rough indication of the influence of monetary conditions on the liquidity preferences of investors, i.e., the plots omit any influence on prices attributed to adjustments in *Stringency*.

While the evidence reported in Tables 4 and 5, and Fig. 1 establishes a link between monetary conditions and aggregate illiquidity, this evidence provides little insight regarding the timing of the adjustments in aggregate illiquidity relative to shifts in monetary policy. To address this omission, Fig. 5 plots aggregate illiquidity innovations for the 100 days before and after a broad shift in Fed policy (*Stance*); this period corresponds with the return values for the zero-cost portfolio reported in Fig. 4.[28] The left-hand plot identifies a clear pattern of increasing aggregate illiquidity (deteriorating liquidity) prior to an expansive policy shift and decreasing illiquidity subsequent to the shift. This pattern coincides almost exactly with what happens to zero-cost portfolio returns plotted in Fig. 4. Specifically, prior to the expansive policy shift, the deterioration in aggregate liquidity conditions corresponds with a decrease in the zero-cost portfolio's return due to the relatively large reduction in the prices paid for illiquid stocks. The improvement in aggregate liquidity following the policy shift coincides with an increase in the returns to the zero-cost portfolio as a consequence of a pronounced increase in prices paid for illiquid stocks. These prominent patterns provide further support for Brunnermeier and Pedersen's (2009) model, which links adjustments in liquidity prices with changing funding conditions. Interestingly, it appears that aggregate liquidity begins to improve before the policy shift, while the relative price increase for illiquid stocks is delayed until several days after the policy shift.

[28] To dampen the daily volatility in the plotted values and improve the visual interpretation, the aggregate illiquidity innovations are averaged over a 5-day period.

The right-hand plot in Fig. 5 suggests that aggregate liquidity improves in the months before a restrictive policy shift. The improvement in liquidity may serve as motivation for the Fed to shift policy to absorb some of the excess liquidity. Subsequent to the policy shift, it appears that aggregate liquidity declines somewhat, but remains fairly stable. As illustrated in Fig. 4, the zero-cost portfolio's return changes little around shifts to a restrictive policy. Thus, changes in aggregate illiquidity have limited implications for liquidity pricing during restrictive policy periods. If funding is readily available and markets are very liquid, changes in funding conditions are unlikely to significantly impact investor preferences regarding security liquidity. Relative to Brunnermeier and Pedersen's (2009) model, restrictive monetary periods are likely to correspond with periods of unconstrained funding for speculators. During such periods, Brunnermeier and Pedersen note that "as long as speculator capital is so abundant that there is no risk of hitting the funding constraint, market liquidity is naturally at its highest level and is insensitive to marginal changes in capital and margins." Thus, changes in stock liquidity and in capital availability have a limited effect on the value of liquidity during periods of high liquidity and abundant capital, which is exactly what our findings suggest.

4.5. Illiquidity and monetary conditions betas

To this point, our results show that the pricing of stock liquidity is strongly related to monetary conditions. The findings are consistent with the hypothesis that monetary conditions proxy for investor funding conditions (as in Brunnermeier and Pedersen, 2009). Additional analysis is warranted, however, to determine whether the relation is driven by very strong return patterns for stocks with the highest and/or lowest liquidity levels. To address this issue, we next examine the entire spectrum of liquidity levels. In Brunnermeier and Pedersen's model, assets become sensitive to funding shocks when speculator funding becomes constrained. During these periods, less liquid assets become more sensitive to changes in funding conditions due to their larger margin requirements. Insofar as monetary conditions are a proxy for the funding conditions of speculators, Brunnermeier and Pedersen's model suggests that less liquid securities should have more price sensitivity to changes in monetary conditions. This hypothesis is consistent with our results in Table 5, which show that illiquidity costs change the most for the least liquid securities when monetary conditions are changing.

We use the following regression framework to explore the hypothesis that sensitivities to monetary conditions vary with the level of stock illiquidity:

$$ret_{t+1} = \gamma + \beta \times \textit{Monetary Conditions}_t + \varepsilon_{t+1}, \tag{3}$$

where ret_{t+1} is the return in month $t+1$ for a liquidity-ranked quintile portfolio. For the monetary conditions measures, *Stringency* and *Stance*, *Monetary conditions*$_t$ is a dummy variable that is one in month t when monetary conditions are expansive and is zero during restrictive conditions. When considering the combination of measures, *Monetary conditions*$_t$ is a dummy variable that is one in month t if monetary conditions are expansive, according to both *Stringency* and *Stance*, and is zero otherwise. We report the estimates of the regression coefficient measuring sensitivity to monetary conditions (the monetary conditions betas) β in Table 7.

In each panel of Table 7, the monetary conditions betas decrease monotonically as one proceeds from the low liquidity (Illiquid) to the high liquidity (Liquid) portfolios. For example, in Panel A, the betas, relative to *Combined*, decrease monotonically from 0.033 to 0.013, across the liquidity spectrum. Almost identical patterns are apparent in Panels B and C. As reported in the final column of the table, the difference in monetary conditions betas between the low and high liquidity portfolios is significant in all cases.

The systematic variation in the monetary conditions betas suggests that the liquidity pricing concerns of investors fluctuate in a systematic manner with monetary conditions. Further, the variation in betas across the portfolios indicates that the relation between monetary conditions and liquidity pricing is not confined to the highest or lowest liquidity stocks, but rather impacts stocks across all levels of liquidity. Low liquidity stocks exhibit by far the greatest sensitivity to changes in monetary conditions. This evidence is consistent with the view, espoused by Brunnermeier and Pedersen (2009), that changes in funding conditions affect all stocks, but have the most serious consequences for illiquid stocks. It is also consistent with the evidence presented in Table 5, showing that changes in monetary conditions have the largest effect on the liquidity of the most illiquid stocks. While similar patterns are apparent for the monetary policy measures independently and in combination, the results indicate that stock returns are most sensitive to changes in the combined monetary conditions measure. The heightened sensitivity to the combined measure is expected given that this measure captures the most pronounced shift in monetary conditions. Overall, the results in Table 7 add additional support for the contention that monetary conditions play an important role in the relation between stock returns and liquidity. Further, the systematic patterns in the reported betas are consistent with the claim that the price adjustments

Table 7

Liquidity and sensitivity to monetary conditions: September 1954 to December 2006.

This table reports the coefficient, β from the following regression:

$$ret_{t+1} = \gamma + \beta \times \textit{MonetaryConditions}_t + \varepsilon_{t+1},$$

where ret_{t+1} is the equal-weighted return in month $t+1$ either from a liquidity-ranked quintile portfolio or from a portfolio long in the quintile of stocks with the lowest liquidity and short in the quintile of stocks with the highest liquidity (Illiquid–Liquid). For the Fed monetary state measures *Stringency* and *Stance*, *Monetary conditions*$_t$ is a dummy variable that is one in month t when the monetary state measure is Expansive and is zero when the measure is Restrictive. For the monetary state measure *Combined*, *Monetary conditions*$_t$ is a dummy variable that is one in month t if the monetary state is Expansive for both *Stringency* and *Stance* and is zero in other months. Newey–West t-statistics are reported in italics for the low liquidity minus high liquidity portfolio. The bandwidth parameter for Newey–West t-statistics is equal to one plus the number of autocorrelated lags that persist in significance at the 5% level.

	Monetary conditions beta (β) Liquidity portfolio						
Monetary state measure	Illiquid	2	3	4	Liquid	Illiquid–Liquid	
Panel A: Amihud illiquidity (ILLIQ)							
Stringency	0.022	0.017	0.017	0.014	0.010	0.013	*t=2.81*
Stance	0.020	0.015	0.012	0.011	0.009	0.012	*t=2.66*
Combined	0.033	0.024	0.022	0.019	0.013	0.020	*t=3.74*
Panel B: Amivest liquidity ratio							
Stringency	0.022	0.017	0.017	0.014	0.010	0.012	*t=2.78*
Stance	0.021	0.015	0.012	0.011	0.009	0.012	*t=2.83*
Combined	0.033	0.025	0.022	0.018	0.013	0.020	*t=3.80*
Panel C: Gibbs estimate of effective costs							
Stringency	0.024	0.017	0.015	0.013	0.011	0.013	*t=2.78*
Stance	0.021	0.014	0.012	0.010	0.010	0.011	*t=2.26*
Combined	0.034	0.024	0.020	0.017	0.015	0.019	*t=3.48*

rationally reflect the varying degrees of illiquidity exposure. Finally, the consistency of the results across both the illiquidity and monetary conditions measures provides added support for the robustness of the findings.

5. Summary and conclusions

A large body of recent research examines the implications of asset and market liquidity for financial markets and security prices. Since liquidity is crucial to well-functioning markets, such attention is with good reason. Because illiquid assets can be difficult and costly to trade, risk-averse agents prefer not to hold illiquid assets, unless they are adequately compensated. An illiquidity premium provides the incentives to bear the costs and risks associated with holding illiquid assets.

Amihud and Mendelson (1986) and Acharya and Pedersen (2005) provide theoretical justification for investors to demand a return premium from illiquid stocks, a relation shown empirically by numerous researchers. Along with Brunnermeier and Pedersen (2009), these theories indicate that time variation exists in the price of liquidity, which suggests that the price is linked to economic dynamics. Brunnermeier and Pedersen link time variation in the illiquidity premium directly to fluctuations in investor funding conditions. Past empirical research links monetary conditions, which we argue reflect funding conditions, to aggregate liquidity. Based on previous theoretical arguments and empirical evidence, we suggest that monetary conditions are an important consideration in understanding how investors price liquidity. We present evidence suggesting that the illiquidity premium demanded by investors decreases during periods of expansive monetary policy, as illiquid stocks increase in price relative to liquid stocks. In contrast, the illiquidity premium demanded by investors tends to be relatively small and stable in the period around a shift to restrictive monetary conditions. The large decrease in the illiquidity premium during monetary expansions is consistent with a larger reduction in the illiquidity costs of the most illiquid stocks (compared to more liquid stocks), which we also observe. The results are robust across alternative measures of both illiquidity and monetary conditions. In addition, a temporal analysis of the return difference between illiquid and liquid stocks confirms the time-series consistency of the relation between monetary conditions and the price of stock liquidity.

The evidence presented in this paper focuses on the inter-temporal variation in the illiquidity premium, which is shown to relate to monetary conditions in a systematic manner. We argue that there is strong justification for the view that changes in monetary conditions represent an underlying factor that influences the price of liquidity. For investors, this evidence suggests that the rewards from holding illiquid assets vary with changes in monetary conditions. For researchers, this evidence suggests that understanding the pricing implications of liquidity requires that researchers consider economic dynamics, and especially monetary conditions, when assessing the price of liquidity.

Appendix. Monetary variables as proxies for monetary conditions

As indicated previously, our two monetary policy measures identify periods where shifts in Federal Reserve monetary policy are revealed (explicitly or implicitly) to market participants. Based on the literature, we rely on the Fed discount rate and the federal funds rate as our proxy variables. These measures are used in lieu of other measures, such as changes in the federal funds target rate, for several reasons. First, the Fed discount rate has existed continuously since the Fed's creation, while the Fed has set a federal funds rate target only intermittently throughout history. Changes in the federal funds target rate are available on the Federal Reserve Web site starting with the first data point September 27, 1982. Second, when both exist, turning points in the Fed discount rate frequently align with turning points in the Fed's federal funds target rate (see Thornton, 1998a). Third, the Fed did not start publicly announcing changes in the federal funds target rate until February 1994, thus, unlike discount rate changes, pre-1994 changes in the target rate would have contained some ambiguity for market participants. Finally, *Stringency* is based on changes in the federal funds rate, which corresponds fairly closely with adjustments in the federal funds target rate. For example, in a regression analysis, variation in the federal funds rate explains 71% of the variation in the federal funds target rate in the post-1982 period.

The efficacy of our monetary policy measures to serve as policy signals requires that the measures satisfy two important characteristics. First, the measures must be readily available to financial market participants on a timely basis. Second, the measures must provide an unambiguous indication of future monetary conditions. As widely publicized interest rates, the Fed discount rate and the federal funds rate clearly satisfy the first requirement. We perform an empirical analysis to address the second issue, i.e., to assess whether the measures identify future changes in the availability of funds. Following Thornton (1998b), we rely on total reserves, non-borrowed reserves, and the adjusted monetary base to measure the effects that Fed actions have on monetary and reserve levels. Monthly observations for total reserves and non-borrowed reserves are taken from the Board of Governors H.3 Release (the Fed's descriptors are TRARR and BOGNONBR, respectively). Monthly observations of adjusted monetary base are obtained from the Federal Reserve Bank of St. Louis (the Fed's descriptor is AMBSL).[29] The percentage change in a funding aggregate over each month $t+1$ is matched with a rate change over the prior month t.

In Table A1, results are reported for *Stringency* and *Stance* both independently and for the intersection of the

[29] Data for total reserves and non-borrowed reserves begin in January 1959.

Table A1
Percentage change in monetary aggregates across monetary conditions.

This table shows the percentage change in monetary/reserve aggregates across different monetary conditions. Changes in aggregates are taken from monthly observations in total reserves, non-borrowed reserves, and the adjusted monetary base (Fed descriptors TRARR, BOGNONBR, and AMBSL, respectively). Monthly changes in total reserves and non-borrowed reserves are from February 1959 through December 2006. Monthly changes in the adjusted monetary base are from September 1954 through December 2006. Changes in aggregates are measured in month $t+1$ based on monetary conditions determined in month t. Monetary conditions measures are detailed in Table 2. Newey–West t-statistics are reported in italics and underneath the monthly average returns. The bandwidth parameter for Newey–West t-statistics is equal to one plus the number of autocorrelated lags that persist in significance at the 5% level. ***,**,* Indicate that the percentage change in monetary policy variables differs significantly across monetary periods at the 1%, 5%, 10% levels, respectively.

Panel Monetary state measure	*A: Percent change in total reserves* *Stringency*			*B: Percent change in non-borrowed reserves* *Stringency*			*C: Percent change in adjusted monetary base* *Stringency*		
Stance	Expansive	Restrictive	All	Expansive	Restrictive	All	Expansive	Restrictive	All
Expansive	0.571%	0.241%	0.447%**	0.708%	0.079%	0.452%*	0.579%	0.575%	0.584%***
Restrictive	0.188%	0.020%	0.069%**	0.707%	−0.195%	0.077%**	0.409%	0.390%	0.418%***
All	0.447%*	0.104%*	0.262%	0.723%***	−0.094%***	0.275%	0.520%*	0.452%*	0.500%

two measures. Panel A of Table A1 reports the average percentage change in total reserves during different monetary conditions. As observed by the bottom row and far right column of Panel A, the percentage increase in total reserves is at least four times larger in expansive relative to restrictive periods. Specifically, based on *Stance*, a signaled shift to an expansive policy is followed by an increase in total reserves of 0.447% versus a 0.069% increase following a restrictive policy shift. The comparable changes in total reserves for expansive and restrictive shifts identified by *Stringency* are 0.447% and 0.104%, respectively. As indicated, both differences are significant at the 10% level or better. In the northwest quadrant of Panel A, results are shown for months when monetary policy conditions are expansive according to both *Stringency* and *Stance*. During these "reinforcing" months, total reserves experience by far the greatest increase, 0.571%. The results in Panels B and C, for non-borrowed reserves and the adjusted monetary base, respectively, support the findings in Panel A and help to establish the robustness of the results.

Overall, the findings in Table A1 provide strong evidence indicating that our monetary policy measures are effective in identifying contrasting monetary conditions.[30] The monetary aggregates indicate that expansive monetary periods, relative to restrictive periods, are associated with significantly greater expansion in the availability of funds. This evidence serves to support the existence of a link between investor funding conditions or funding liquidity, per Brunnermeier and Pedersen (2009), and our monetary policy measures. Furthermore, the evidence is consistent with the contention that adjustments in monetary and reserve aggregates correspond with prior changes in rates that are controlled directly by the Fed (the discount rate) and influenced by the Fed (the federal funds rate).

[30] Jensen, Mercer, and Johnson (1996) provide similar evidence with monetary aggregates and the Fed discount rate.

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