Were there Liquidity Black Holes during the Great Depression?  
An Analysis of the U.S. Government Bond Market

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1. Introduction

According to many observers, security market illiquidity has played an important role in post-WWII financial crises. For example, Amihud, Mendelson and Wood (1990) argue that beliefs about liquidity were badly shaken in the days leading up to the 1987 stock market crash as unanticipated selling pressure produced unusual price declines and this reassessment of liquidity caused prices to fall. Miller (1990) draws a parallel between the 1987 crash and bank runs where rational agents sell out of fear that selling by others will lead to large price declines when markets become illiquid. More recently, illiquidity was implicated in the 1998 collapse of Long Term Capital Management:

In August 1998, after the Russian government had defaulted on its debts, liquidity suddenly evaporated from many financial markets, causing asset prices to plunge. LTCM tried to stave off disaster by selling assets as the value of its portfolio fell—but the lack of liquidity in markets prevented it from selling enough. The value of its portfolio plummeted, until the Federal Reserve twisted the arms of a group of banks to mount a rescue.\(^1\)

The Bank of International Settlements (1999) reached the same conclusion, noting that bid/ask spreads for on-the-run U.S. Treasuries rose by a factor of ten during the crisis and that dealers were unwilling to make markets in more seasoned Treasuries.\(^2\)

While security market illiquidity has played an important role in recent crises, economic historians have largely ignored its influence. For instance, in their classic study of the Great Depression Friedman and Schwartz (1963) argue that a flight to liquidity during the 1931-33 banking crises caused the term structure of interest rates to become steeper, but they do not consider whether market liquidity changed and influenced asset prices. Temin (1976) explicitly rules out this possibility: “All the bonds held in bank portfolios were sold on organized markets. There is no suggestion that any of them was more liquid than the others, that is, that one could be sold at shorter notice than others…” (p. 105). Wigmore (1985, p. 401) notes that secondary

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2. Fleming (2000) shows that market depth quoted by dealers also fell significantly during the crisis.
markets for many bonds “disappeared” in early 1932, but does not examine the source of the problem or consider the asset pricing implications.

In contrast, contemporary observers such as Berle and Pederson (1934) warned that security market liquidity was vulnerable to collapse:

About one-third of the total portfolio of the banking system was represented by investments. This does not seem unduly large, if – but only if – the exchange and shiftability mechanism is in smooth and working order. So long as this is true the investment item of the portfolio is more liquid than the loans and discounts. But in the event of a difficulty with the exchange mechanism, the whole investment portfolio is likely to freeze up at once… the danger is that the entire system on which the liquidity is based will prove unreliable in case of a crisis. (p. 96-97)

Similarly, Cyril James (1935) observed that, “neither economic theory nor financial experience offer any guidance as to methods or policies by which the quality of real liquidity could be conferred on such assets as stocks and bonds” and that society should “frankly recognize the fact that such assets are not liquid and modify our financial practices accordingly” (p. 140). Henry Simons (1935) also wrote about “the dangerous illusion” of liquidity (p. 7).

This paper examines the role of liquidity in the financial market collapse of the Great Depression. Specifically, we focus on the market for United States government bonds between 1928 and 1933 and address three questions. First, did market liquidity, measured using quoted and effective bid/ask spreads, fluctuated during the Great Depression? Second, was illiquidity priced? That is, did expectations of higher illiquidity lead to lower bond prices and higher expected returns (liquidity premia)? 3 Finally, why did markets become less liquid?

Regarding the last question, we consider two hypotheses. The first is that illiquidity reflected macroeconomic shocks. Focusing on recent U.S. data, Chordia, Sarkar and Subrahmanyam (2005) argue that a “flight to quality” generated by negative macro news can

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3 We are unaware of any studies that examine liquidity risk in bond markets during the Great Depression. Researchers have documented significant commonality in time-varying liquidity across security markets (Chordia, Roll and Subrahmanyam (2000), Huberman and Halka (2001) and Hasbrouck and Seppi (2001)) and shown that marketwide illiquidity risk is priced (Jones (2002), Amihud (2002), Pastor and Stambaugh (2004) and Acharya and Pedersen (2005)). However, only Jones (2002), who focuses on annual stock returns, utilizes pre-WWII data.
raise price and order flow risks borne by dealers in both equity and bond markets, leading to
marketwide changes in liquidity.\textsuperscript{4} Also, tighter monetary policy raises price and order flow risks
and increases the cost of financing dealer inventory across markets.\textsuperscript{5} Overall, this line of research
links “macro liquidity” (aggregate money flows) and “micro liquidity” (bid/ask spreads,
immediacy, depth and resiliency) across markets.

Alternatively, liquidity might suddenly disappear when markets enter a “liquidity black
hole.” When markets enter a liquidity black hole, feedback from price changes to order flow
turns positive (price declines lead to more sell orders) and, much like a tropical storm which
gathers energy as it develops, collapsing prices and market distress feed on themselves.\textsuperscript{6} Positive
feedback has several possible causes. First, it can result from market-sensitive risk management
systems, such as portfolio insurance in 1987 or stop-loss systems in 1929 (Gennaioli and Leland
(1990)). Second, widespread use of a common information source by traders can produce
positive feedback (Persaud (2003)). Third, agency problems within financial institutions may
lead to daily trading limits which shorten investment horizons (Morris and Shin (2004)). Finally,
Bernardo and Welch (2004) examine the case of “financial market runs” where investors sell as
prices fall out of fear that they will have to liquidate securities before prices return to their
fundamental value and during a period when market makers, because they already hold large
inventories, are reluctant to absorb additional order flow.\textsuperscript{7} This creates an environment where,
“Prices and market making inventories are driven by the fear of future liquidity shocks, not by
liquidity shocks themselves. Liquidity shocks might loom in the future but cause a run today.”\textsuperscript{8}

\textsuperscript{4}The link between macroeconomic shocks and liquidity is motivated by inventory-based microstructure
models (see Demsetz (1968), Garman (1976), Stoll (1978a), Stoll (1978b), Amihud and Mendelson (1980),
Ho and Stoll (1981) and O’Hare (1997)). These models predict that unbalanced order flow or price
volatility increase spreads to compensate dealers for bearing greater risk. In addition, the level of interest
rates influences spreads when market makers rely on leverage and face short-selling constraints.
\textsuperscript{5}Chordia, Roll and Subrahmanyam (2001) show that marketwide liquidity is negatively related to the
federal funds rate.
\textsuperscript{6}Cohen and Shin (2002, 2003) document positive feedback between order flow and prices in U.S. Treasury
\textsuperscript{7}Their model is similar to bank run models pioneered by Diamond and Dybvig (1983).
\textsuperscript{8}Bernardo and Welch (2004, p. 139).
According to Morris and Shin (2004), liquidity black holes are not simply instances of large price changes. Such changes often occur after macroeconomic news is released, with markets quickly regaining composure once prices incorporate the new information. Rather, liquidity black holes can arise independent of macroeconomic shocks and take on a life of their own. Thus one strategy to identify liquidity black holes is to isolate movements in marketwide liquidity than cannot be directly linked to macroeconomic disturbances.

To examine these issues, we use a new data set of dealer quotations and transaction prices for eight U.S. government bonds hand-entered from daily issues of the *New York Times* between January 1928 and December 1933. Utilizing high-frequency bid/ask spreads, we are able to examine microstructure behavior in detail. Moreover, government bond markets are more liquid than other security markets so this analysis produces a lower bound estimate of the costs associated with illiquidity during the Great Depression.

The paper provides several important findings. First, there is significant cross-sectional and temporal variation in government bond market liquidity during the Great Depression. Consistent with inventory-based models, government bonds with smaller volumes outstanding had larger and more variable bid/ask spreads. Although increased illiquidity is associated with macroeconomic shocks (i.e., changes in monetary policy, bank runs, etc.) in some instances, in others it appears to take on a life of its own. This is particularly true beginning in 1931 when many markets seize up. Second, there is evidence that marketwide liquidity risk was priced. That is, consistent with Amihud (2002) we find that increases in expected illiquidity are associated with higher realized returns, while unexpected illiquidity shocks lead to lower returns. Finally, the empirical relationship between bond returns and illiquidity holds after we control for changes in monetary policy, bank panics and other macroeconomic shocks. This finding suggests that liquidity black holes were present during the Great Depression and influenced government bond prices.
The paper is outlined as follows. The next section discusses the illiquidity measures and examines their relationship with macroeconomic shocks. Section 3 presents the empirical model used to test whether liquidity was priced and the results are discussed in Section 4. Section 5 concludes the paper.

2. Government Bond Market Liquidity

According to Harris (2003), a security market is liquid when investors can quickly trade a large quantity, at low cost, without disturbing prices. Fleming (2003) examines different measures of Treasury market liquidity using data from the past decade and concludes that bid/ask spreads are the best metric. Thus we use bid/ask spreads to measure government bond market liquidity during the Great Depression. We begin by discussing data and measurement issues and then examine the behavior of illiquidity during the early part of the Great Depression.

2A. Data and Measurement Issues

We focus on the eight United States government bonds traded on the New York Stock Exchange (NYSE) between 1928 and 1933. Table 1 shows that these bonds differed in several important respects: a) date of issue, b) coupon rate, c) call date, d) maturity date and e) volume outstanding. Based on call dates, the two First Liberty Loans had the shortest life, while the Treasury 4 ¼ of 1947-52 had the longest. The Fourth Liberty 4 ¼ of 1933-38 (the “Fourth Liberty”) had, by far, the largest volume outstanding with almost $7.0 billion issued, more than three times the amount of the next largest issue (First Liberty 3 ½ of 1932-47). The Treasury 3 3/8 of 1940-43 was the smallest with just under $0.4 billion issued.

Daily data for each bond was hand-entered from the column entitled “Bond Sales on the New York Stock Exchange,” contained in the New York Times. Four pieces of data were collected for each security: 1) transaction volume, 2) last transaction price, 3) closing bid price,

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9He argues that price impact (the responsiveness of price to net order flow) is also a good measure of liquidity but lacks the spread’s ease of use. In addition, trading volume is a weak proxy for liquidity because both high and low levels of trading activity are associated with low liquidity.

10Cecchetti (1988) uses the same source, but records bond prices on the last trading day of the month rather than each trading day.
and 4) closing asked price. Prices are for a $100 face value bond and expressed in 32nds of a point. The NYSE was open on 1,612 days between January 1, 1928 and December 31, 1933. Bid and ask quotes were reported by the *Times* on each of these days, even when no trades took place. Because of occasional recording problems, the actual number of quotes we were able to enter ranges from 1,597 to 1,612. The number of days that transaction prices were recorded ranges from 1,240 for the Treasury 3 ¾ of 1946-56 to 1,612 for the actively traded Fourth Liberty.

It is important to note that by the 1930s the majority of government bonds traded, not on the NYSE, but in the over-the-counter (OTC) market where dealers bought and sold bonds for their own account.\(^{11}\) To account for this the *Times* began reporting bid and ask quotes of OTC dealers as early as 1918.\(^{12}\) Thus our price quotations are representative of the entire government bond market and not just the small segment located on the NYSE.

Using daily data from the *Times*, we estimate two different bid/ask spreads for each of the government bonds:

a) Quoted Spread – The difference between asked and bid prices quoted at the end of the day.

b) Effective Spread – The absolute difference between the last transaction price and the midpoint of the closing bid and ask quote, multiplied by two.

In addition, we follow Chordia, Roll and Subrahmanyam (2001) and use a cross-bond average to measure overall (marketwide) liquidity of the government bond market:

\[
ILLIQ_{m,t,d} = \frac{1}{p} \sum_{i=1}^{p} ILLIQ_{i,t,d}
\]


\(^{12}\)A note to the “Bond Sales on the New York Stock Exchange” column in 1918 stated that, “Inasmuch as the bulk of business in United States Government bonds is done over the counter, and not on the Stock Exchange, THE TIMES gives the following quotations, obtained from bond dealers.” *New York Times*, January 23, 1918.
where $ILLIQ_{i,t,d}$ is either the quoted or effective spread for bond $i$, on day $d$ of month $t$. The equal-weighted average is taken over the $p$ bonds for which an illiquidity measure is available on day $d$.

**2B. Liquidity Dynamics of Individual Bonds**

Table 2 provides sample means and variances for individual spreads. Using either the quoted or effective spread, the Fourth Liberty was the most liquid bond. For instance, the mean quoted spread for the Fourth Liberty was 5.78 cents per $100$ bond, almost four cents lower than the next lowest quoted spread. The mean effective spread for the Fourth Liberty was 5.52 cents, suggesting that this security typically traded (slightly) within the quoted spread. As noted above, the Fourth Liberty had the largest volume issued and was the most actively traded bond with sales recorded on each day the NYSE was open. In contrast, the least liquid bond was the Treasury 3 3/8 of 1943-47, with a mean quoted spread almost three times as large as that for the Fourth Liberty. This bond also had a relatively small volume issued. Overall, smaller issues tend to be less liquid and this cross-sectional relationship is consistent with inventory models which emphasize a) the negative relationship between balanced order flow and the risk borne by dealers and b) scale economies.

As we discuss below, liquidity risk – the variability of liquidity over time – is potentially more important for asset pricing than the average level of liquidity. One simple measure of liquidity risk is the sample variance of spreads, which are shown in Table 2. By this measure, the Fourth Liberty had the lowest liquidity risk while the Treasury of 1940-43 (quoted spread) and Treasury of 1943-47 (effective spread) had the highest. In fact, the variances for these latter two bonds are over ten times as large as the variance for the Fourth Liberty.

To quantify covariation of the quoted spreads, Table 3 presents pair-wise correlation coefficients. The highest correlation (0.594) is for the two bonds with the highest average spread:

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13 The sample begins July 17, 1928 when the Treasury 3 3/8 of 1940-43 began trading.
14 See Shen and Starr (2002) for a nice discussion of the link between trading volume and spreads.
the Treasury of 1940-43 and Treasury of 1943-47. In contrast, spreads for the Fourth Liberty have the lowest average correlation with all other spreads (0.169). This finding is consistent with the empirical work of Acharya and Pedersen (2004), which shows that securities with the highest average illiquidity tend to have the highest commonality in liquidity with other securities.

Figure 1 illustrates the relative liquidity risk of the bonds by plotting 25-day moving averages of daily quoted spreads for the 1) First Liberty Convertible of 1932-47, 2) Treasury of 1943-47, and 3) Fourth Liberty. The differences in means and variances of the quoted spreads are clearly apparent in Figure 1. Spreads for the Treasury of 1943-47 often exceed $0.30 and occasionally rise above $0.50. In contrast, spreads for the Fourth Liberty rarely rise above $0.08.

The period from September 1931 through mid-1932 is particularly illuminating. The spread for the Treasury of 1943-47 rose in October 1931, fell in November, peaked in December and remained high throughout the first half of 1932. The spread for the First Liberty Convertible follows a similar pattern, but its behavior from December onward is less extreme. The spread for the Fourth Liberty rises in October 1931 but remains low after falling in November.

The disparate behavior suggests that markets for the Treasury of 1943-47 and, to a lesser extent, the First Liberty Convertible entered a liquidity black hole toward the end of 1931. We know that modern U.S. Treasury markets regain their composure quite rapidly after the release of macroeconomic news (see Fleming and Remolona (1999)). This appears to be the case for the Fourth Liberty, with a bid/ask spread that rises temporarily following Great Britain’s departure from the gold standard in September and tightening of U.S. monetary policy in early October of 1931. In contrast, the spread for the Treasury of 1943-47 remains elevated throughout 1932. These two bonds are driven by the same fundamentals so it is difficult to attribute the disparate behavior of their spreads to macroeconomic news. Rather, like a tropical storm, illiquidity in the market for the Treasury of 1943-47 appears to have taken on a life of its own.

Anecdotal evidence also suggests that bond market behavior changed after Britain left gold and that illiquidity, rather than fundamentals, was driving prices:
The continued inactivity of the bond market had already produced a weakness on the part of dealers on the bid side. The announcement by England of the discontinuance of the gold standard brought about not only a further weakening, but in many cases, the complete withdrawal of bids in many classes of bonds, particularly foreign issues. This in turn occasioned price declines throughout the list to unusually low levels which had, in many instances, little or no relation to the intrinsic worth of the securities.15

The idea that security priced deviate from their fundamental value is consistent with recent theoretical work of Longstaff (2004) who argues that institutional factors matters more when liquidity disappears. By January 1932, market makers had completely withdrawn from some markets: “Practically all of this business was on an order basis because few dealers were willing to make commitments.”16 After the Federal Reserve began their aggressive open market purchase program in March 1932 Harvard economist Parker Willis (1934) observed that:

As time went on, the Reserve Banks became generally “frozen,” their assets consisting of Government obligations whose marketability depended wholly upon the capacity of the Reserve Banks themselves to absorb Government obligations of all varieties. (p. 102)

One explanation for this behavior is that increased uncertainty about the Federal Reserve’s policy regime made the emergence of liquidity black holes more likely after September 1931. An important insight from theoretical models is that a collapse in liquidity is more likely when traders use past price movements to infer future price changes (see Gennotte and Leland (1990)). In addition, work in international finance argues that expectations become more extrapolative when the policy regime becomes more uncertain,17 while economic historians have provided evidence that uncertainty about the Federal Reserve’s regime increased dramatically after September 1931.18 Combined, this work suggests that liquidity black holes were more likely after Britain left the gold standard.

15Acceptance Bulletin (September 1931, p. 15).
16Acceptance Bulletin (January 1932, p. 27).
17For example, Paul De Grauwe (1996) argues that exchange rates deviate from fundamental value more when expectations are not anchored by a credible exchange rate regime and forecasters are forced extrapolate recent trends.
18See Ferderer and Zalewski (1996) and Hallwood, MacDonald and Marsh (2000).
2C. Dynamics of Marketwide Illiquidity

Figure 2 shows 25-day moving averages of marketwide quoted and effective spreads defined in (1). The marketwide averages reflect the general level of liquidity in the government bond market – rather than idiosyncratic factors affecting individual markets – that is less diversifiable. Although there are a few periods where effective and quoted spreads differ (e.g., following the October 1929 stock market crash), the series display a high degree of covariation. To examine this more closely, Figure 3 plots the difference between the marketwide quoted and effective spreads. The differences are relatively small and transitory suggesting that transactions often took place at or near quoted prices. Given the similarity between the two series, we focus on the quoted spread in the rest of the paper.

As discussed above, the stance of monetary policy should affect bid/ask spreads by influencing the cost dealers pay to finance inventory. Also, policy changes can increase price and order flow risk borne by dealers, leading them to raise spreads. To examine these relationships, Figure 4 shows the marketwide quoted spread along with the Federal Reserve Bank of New York rediscount rate. The covariation of the two series is striking. The rediscount rate was increased three times in 1928 and once again in August 1929 to stem stock market speculation. Following the October 1929 crash it was lowered eight times over the next 20 months. Monetary policy was tightened in October 1931 to prevent capital outflow after Britain left the gold standard and again in March 1933. The marketwide bid/ask spread follows the same general trend as the rediscount rate and often spikes when the rediscount rate is increased. However, there are many illiquidity spikes that occur without a change in monetary policy and relative level of the two series appears to change beginning in 1931.

To further examine the link between money market conditions and bond market liquidity, Figure 5 illustrates the bid/ask spread and the renewal rate on stock market call loans. The call rate reflects both a) the stance of monetary policy and b) stock market activity — increased (decreased) demand for stocks bought on margin leads to rising (falling) call rates. Note that the
first two illiquidity spikes in 1929 are associated with higher call rates, while the third spike in June 1929 occurs while the call rate falls. A positive association between the two series should arise if heavy stock buying drove up call rates and bond dealers raised spreads to make up for the higher cost of financing inventory. The two series should move in the opposite direction if a dramatic movement out of stocks reduced the demand for call money and created significant price and order flow risk for government bond dealers. While the marketwide spread and call rate move together early in the sample, the correlation appears to breakdown and the relative levels diverge starting in 1931.

The banking crises that occurred starting in late 1930 are another potential source of bond market illiquidity. If panicky depositor withdrawals prompted a flight to liquidity by banks this should increase the price and order flow risk borne by market makers and lead them to increase spreads. To examine this relationship, we follow Friedman and Schwartz (1963) and use the ratio of bank deposits to bank reserves as a measure of banking distress. Monthly values of this variable are shown in Figure 6 along with our illiquidity variable.

Beginning in late 1929, the deposit-reserve ratio trends downward and the rate of decline increases after Britain left the gold standard in September 1931. Notable declines in the ratio occur during: a) the October 1929 stock market crash, b) the first banking crisis (November 1930), c) the third banking crisis (December 1931), d) the open market purchase program carried out by the Federal Reserve between March and May of 1932, and e) the fourth banking crisis (March 1933). Importantly, each of these large declines in the deposit-reserve ratio is either preceded or followed by an illiquidity spike. For example, the largest decline in the ratio is in December 1931, a month bracketed by two of the largest illiquidity spikes observed in our sample. The timing of the two series suggests that bank panics caused bond markets to become less liquid by prompting fire sales of securities. However, the causality could run in the other direction with bond market illiquidity generating asset price deflation, which induced depositors to run the banks.
Overall, there is evidence that illiquidity can be explained by macroeconomic shocks. However, much of the illiquidity, particularly in the second half of the sample, appears to be independent of macro forces and take on a more autonomous nature. This is consistent with illiquidity dynamics that characterize black holes.

3. Pricing Illiquidity: Specification Issues

The rest of the paper examines whether the illiquidity observed above was priced. This section presents the empirical model used to test this proposition and the results are discussed in the following section.

In seminal work, Amihud and Mendelson (1986) argue that small differences in liquidity can have large effects on prices when transaction costs are incurred repeatedly over the life of a security. After controlling for market risk (CAPM betas), they provide cross-sectional evidence that stocks with higher bid/ask spreads have higher expected returns. More recently, scholars have shifted focus from the average level of liquidity to liquidity risk—the risk arising from unpredictable changes in liquidity over time. For example, Pastor and Stambaugh (2003) investigate whether marketwide liquidity is a priced stated variable and provide cross-sectional evidence that stocks whose returns are more sensitive to marketwide liquidity fluctuations have higher expected returns. Acharya and Pedersen (2004) present a model which shows how both the level of liquidity and liquidity risk affect security prices and provide empirical evidence that several types of liquidity risks are priced.

Given the small number of cross-sectional units in our sample (i.e., eight government bonds), we follow Amihud (2002) and focus primarily on the time-series relationship between marketwide illiquidity and expected bond returns. Amihud examines stocks traded on the NYSE between 1963 and 1997 and constructs a monthly price-impact measure of liquidity – the daily

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19 Other studies provide similar evidence in a variety of settings. See Kamara (1994), Brennan and Subrahmanyam (1996), Shen and Starr (1998), Longstaff (2004) and others.

20 One interesting finding is that assets whose liquidity declines the most when market returns fall have the highest liquidity premium.
ratio of absolute returns to trading volume summed over the month – aggregated across stocks. He shows that *expected* marketwide illiquidity is positively associated with expected excess returns and *unexpected* illiquidity lowers contemporaneous stock prices. This latter effect occurs because innovations to illiquidity raise expected illiquidity (when illiquidity is persistent) and contemporaneous prices must fall to insure that expected returns rise. Amihud also shows that stock returns of smaller firms are more sensitive to aggregate illiquidity and argues that this could explain the small-firm effect documented in the literature. Our approach follows Amihud (2002) closely.

To examine whether marketwide liquidity was priced, we measure monthly bond returns as

\[ R_t = \frac{(P_t + AI_t) + C_t - (P_{t-1} + AI_{t-1})}{P_{t-1} + AI_{t-1}} \]

where \( P_t \) is the bond price (mean of bid and ask prices) quoted on the last trading day of month \( t \), \( AI_t \) is accrued interest (semi-annual coupon payment scaled by the ratio of days since the last payment date to the days between payment dates), and \( C_t \) is the semi-annual coupon payment (if any) paid during \( t \). The monthly return to a portfolio of government bonds (hereafter the “market return”) is an equally-weighted average of individual bond returns

\[ R_{m,t} = \frac{1}{p} \sum_{i=1}^{p} R_{i,t} \]

where \( R_{i,t} \) is the return to bond \( i \) over month \( t \) and \( p \) is the number of bonds.

We measure marketwide illiquidity at monthly frequencies by averaging the daily figures discussed in the previous section:

\[ ILLIQ_{m,t} = \frac{1}{n} \sum_{d=1}^{n} ILLIQ_{m,t,d} \]
where $ILLIQ_{m,t,d}$ is the equal-weighted mean of quoted bid/ask spreads for government bonds on day $d$ of month $t$ and $n$ is the number of trading days in the month.

Figure 7 shows the government bond market return (3) and government bond market illiquidity (4). The figure shows a clear inverse relationship between the two series. Note that the seven largest negative monthly returns all occur in the second half of the sample and each is associated with high illiquidity. The illiquidity spikes in 1929 are also associated with negative bond returns, but these negative returns are of a much smaller magnitude than those observed in 1931 through 1933. This observation suggests that either a) the impact of illiquidity on bond returns increased in the second half of the sample or b) other factors driving bond returns became more volatile in the latter period. We return to this issue below.

To examine the time-series relationship between returns and illiquidity, we follow Amihud (2002) and distinguish between expected and unexpected illiquidity. If liquidity is priced, expectations of greater illiquidity should be associated with higher expected returns. That is, expected returns contain a liquidity premium. However, because expected returns are proxied by realized returns, unexpected illiquidity also matters. This is because shocks to illiquidity lead to revisions in expectations about future illiquidity which, to the extent that liquidity is valued by investors, are reflected in contemporaneous prices and realized returns.

Formally, the relationship between expected bond returns and expected illiquidity is conjectured to be:

$$R_{m,t}^E = \alpha + \beta ILLIQ_{m,t}^E$$

21This approach was pioneered by French, Schwert and Stambaugh (1987), who explored the impact of expected and unexpected stock market volatility on stock returns. Using a portfolio of NYSE stocks from 1928 to 1984, French et al. find a weak positive relation between realized returns and expected volatility and a strong negative relation between realized returns and unexpected volatility. They interpret the latter finding as indirect evidence that volatility is priced.
where \( R_{m,t}^E \) is the expected market return over month \( t \), \( ILLIQ_{m,t}^E \) is expected marketwide illiquidity for month \( t \), and \( \alpha \) and \( \beta \) are coefficients.\(^{22}\) Both expectations are based on information available at the end of \( t-1 \) as we discuss below. If \( \beta > 0 \) there is evidence that liquidity is priced.

The relationship in (4) is difficult to test because both variables are not directly observable. To proxy expected market illiquidity, we assume that illiquidity follows an autoregressive process:

\[
ILLIQ_{m,t} = \theta + \rho ILLIQ_{m,t-1} + v_t
\]

where \( \theta \) and \( \rho \) are parameters that measure drift and persistence, respectively, and \( v_t \) is the innovation to illiquidity. To predict illiquidity for month \( t \) based on information available at the end of month \( t-1 \), investors are assumed to use

\[
ILLIQ_{m,t}^E = \hat{\theta} + \hat{\rho} ILLIQ_{m,t-1}
\]

where \( ILLIQ_{m,t}^E \) is expected illiquidity and \( \hat{\theta} \) and \( \hat{\rho} \) are coefficients estimated from historical data. Using (6) we can solve for unexpected illiquidity:

\[
ILLIQ_{m,t}^U = v_t = ILLIQ_{m,t} - (\hat{\theta} + \hat{\rho} ILLIQ_{m,t-1})
\]

where the \( u \) superscript denotes unexpected.

Turning attention to the left side of (4), we use the fact that expected returns equal realized returns minus unexpected returns (the error in forecasting returns). Thus (4) can be written as

\(^{22}\) Amihud (2202) focuses on excess stock returns by subtracting three-month Treasury bill rates from stock returns. In contrast, we focus on simple returns because it is not clear what asset is more liquid than government bonds. We experimented with excess returns obtained by taking the difference between government bond returns and the discount rate on bankers’ acceptances, but the results were generally the same.
\begin{equation}
R_{m,t} = \alpha + \beta ILLIQ_{m,t}^E + u_t
\end{equation}

where \( R_{m,t} \) is the realized return and \( u_t \) is the unexpected return for month \( t \).

Amihud (2002) argues that unexpected illiquidity and unexpected returns are inversely correlated, \( \text{cov}(v_t, u_t) < 0 \), when: a) liquidity is priced (\( \beta > 0 \)), and b) innovations to illiquidity are persistent (\( \rho > 0 \)). Persistence implies that a shock to illiquidity causes investors to revise their expectations about future illiquidity. If liquidity is priced, contemporaneous bond prices must fall in response to an illiquidity shock to raise future returns to holding bonds (with coupon payments fixed). Thus there should be a negative relation between illiquidity shocks and realized returns.

To model this effect, we add unexpected illiquidity to (8)

\begin{equation}
(8') \quad R_{m,t} = \alpha + \beta ILLIQ_{m,t}^E + \phi ILLIQ_{m,t}^U + \epsilon_t
\end{equation}

where \( ILLIQ_{m,t}^U \) is given in (7), \( \phi \) is a parameter and \( \epsilon_t \) is an error term purged of innovations to realized returns produced by illiquidity shocks. If liquidity is priced, we should observe \( \beta > 0 \) and \( \phi < 0 \).

To test the null hypothesis that liquidity is priced, we proceed as follows. First, (5) is estimated to obtain \( \hat{\theta} \) and \( \hat{\rho} \). Second, these parameters are plugged into (7) to identify unexpected illiquidity. Third, lagged illiquidity and unexpected illiquidity are inserted into (8') to obtain:

\begin{equation}
R_{m,t} = a + b ILLIQ_{m,t-1} + c ILLIQ_{m,t}^U + \epsilon_t
\end{equation}

where: \( a = \alpha + \beta \theta \), \( b = \beta \rho \) and \( c = \phi \). If liquidity is priced we should observe \( b > 0 \) and \( c < 0 \).

Stambaugh (1999) has shown that in cases where the predictive variable (illiquidity in our case) is governed by an AR(1) process and the residuals from this process are correlated with
those from the return regression, (i.e., cov(\(v_t\), \(u_t\)) < 0 as discussed above), the OLS estimate \(\hat{b}\) is biased in finite samples. To correct for this bias, we follow Amihud and Hurvich (2004) and apply OLS to (5) to obtain \(\hat{\rho}\), and transform this coefficient to obtain the corrected estimator:

\[
\hat{\rho}^c = \hat{\rho} + \frac{(1 + 3\hat{\rho})}{n} + \frac{3(1 + 3\hat{\rho})}{n^2}
\]

where \(n\) is the number of observations in the OLS regression. This corrected estimator is used in (7) to obtain corrected shocks to unexpected illiquidity, which we plug into regression (9). This regression produces corrected estimate of \(b\) and \(c\) (\(b^c\) and \(c^c\)), both of which are unbiased. To correct for bias in the standard errors associated with \(b^c\), we use the approach outlined in Amihud and Hurvich (2004).

Finally, we seek to determine whether the presence of liquidity black holes helps to explain the relationship in (9). One reason we might observe a relationship between bond returns and illiquidity is that both variables are responding to a third variable. For example, a monetary policy-induced rise in interest rates could lead to lower bond returns and higher bid/ask spreads. Similarly, a flight to liquidity during a bank run could cause both liquidity and realized bond returns to fall. In both of these examples, macroeconomic shocks rather than unstable order flow-price dynamics (liquidity black holes) are responsible for the relationship between illiquidity and returns. To control for macroeconomic shocks, we estimate a general version of (9)

\[
R_{m,t} = a + b ILLIQ_{m,t-1} + c ILLIQ^{U}_{m,t} + d X_t + \varepsilon_t
\]

where \(X_t\) is a vector of macro shocks and \(d\) is a coefficient vector. If illiquidity explains bond returns simply because both are responding to the macro shocks, inclusion of \(X_t\) in the model should eliminate the explanatory power of illiquidity. If illiquidity continues to explain bond returns after controlling for macro disturbances, however, there is evidence that liquidity black holes were present and influenced returns.
4. Empirical Results

This section discusses the empirical results for the bond pricing models. We first present estimates of the autoregressive model for marketwide illiquidity (5) and then discuss results for the simple return model (9) and models which include macro shocks (10).

OLS estimates for the autoregressive model fit to market illiquidity, (5), are given as follows:

\[ ILLIQ_{m,t} = 0.045 + 0.646 ILLIQ_{m,t-1} \]

\[ (3.76) \quad (7.11) \]

\[ n = 72, \quad R^2 = 0.41, \quad D-W = 2.02 \]

where t-statistics are given in parentheses below the coefficient estimates. Using the approach proposed by Amihud and Hurvich (2004), the bias-corrected autoregressive coefficient \( \hat{\rho} \) is 0.689 and the corrected intercept \( \hat{\theta} \) is 0.039. Interestingly, the explanatory power of the autoregressive model falls significantly when we split the sample in half – the adjusted \( R^2 \) is 0.61 for the 1928-1930 period and 0.23 for the 1931-1933 period. However, Chow tests reveal that we cannot reject the null hypothesis of parameter stability. Thus we follow Amihud (2002) and French et al. (1987) and use coefficient estimates obtained from the entire sample to model investor expectations.

Table 4 provides estimates of (9) for the returns to the eight government bonds and the equally-weighted government bond portfolio.\(^{23}\) The statistical fit of the models is quite good. The adjusted R-squared is near or above 30 percent for all but one of the models and as high as 38 percent. In each case the coefficient on lagged illiquidity is positive, consistent with the hypothesis that liquidity is priced, although we cannot reject the null that \( b^c \) is equal zero at conventional levels of significance. In contrast, the coefficients on unexpected illiquidity are negative in each model and statistically significant at high levels of confidence. The relative

\(^{23}\)The t-statistics are calculated with standard errors corrected for heteroskedasticity and autocorrelation using the Newey-West method. In addition, the standard error for \( b^c \) is corrected for bias using the approach outlined in Amihud and Hurvich (2004).
strength of expected versus unexpected liquidity is consistent with previous research which uses these types of models (see French et al. (1987)).

The sizes of the coefficients in Table 4 also appear to be economically meaningful. For example, the coefficient of -27.17 on ILLIQ^U for the Treasury of 1943-47 suggests that an unanticipated increase in the marketwide quoted spread of $0.10 leads to a 2.72 percentage point decline in the monthly return. This is a relatively large change for a government bond. Overall, these findings provide strong evidence that liquidity was priced in the government bond market between 1928 and 1933.

Recent research in finance interprets coefficients like those shown in Table 4 as measures of liquidity risk — akin to beta measures of market risk in the CAPM — because they show how sensitive returns of specific securities are to changes in marketwide liquidity (see Amihud (2002), Pastor and Stambaugh (2004) and Acharya and Pedersen (2005)). Moreover, liquidity risk is shown to be correlated with various security characteristics. For instance, Amihud (2002) shows that returns of smaller, illiquid stocks are more sensitive to market illiquidity than returns of larger, liquid stocks because the latter stocks are more attractive during periods of low liquidity. Our results are consistent with this finding. As we saw above (Table 2), the Fourth Liberty was the most liquid of the eight government bonds. Table 4 shows that this bond had the second lowest liquidity risk measured by the magnitude of the coefficients on expected and unexpected marketwide illiquidity. This finding is consistent with the hypothesis that the Fourth Liberty was relatively more attractive when marketwide liquidity fell.

Several versions of the basic model were estimated to check if the results are sensitive to measurement choices. Alternatives included: a) log transformations of the illiquidity variable, b) returns exclusive of accrued interest, c) excess returns measured net of the discount rate on 30-

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24The only bond with lower liquidity risk—the First Liberty Convertible of 1932-47—was one that had a shorter maturity (measured by the call date).
day bankers’ acceptances, and d) inclusion of additional lags and time trends in the autoregressive model for illiquidity. The results were not sensitive to these changes.

One change that does make a difference, however, is to split the sample in half. Table 5 illustrates results for models fit using data from 1928-1930 while Table 6 shows results for the 1931-1933 period. Two differences across the samples are striking. First, the adjusted $R^2$s are twice as large, on average, for the 1931-1933 period. This finding suggests that illiquidity was more important for bond pricing during the second half of the sample. It is also consistent with our conclusion in Section 2 that changes in monetary policy and stock market gyrations, by influencing the cost of financing inventories and generating order flow risk, had a more important impact on bond market liquidity in the first part of the sample and that liquidity black holes, with autonomous illiquidity spikes and large bond price declines, were more important beginning in 1931.

Second, the coefficients on $ILLIQ_{t-1}$ decline in size and statistical significance in the 1931-1933 period, while the coefficients on $ILLIQ_{t}^{u}$ take on much larger negative values in this period. That is, expected illiquidity was more important for bond pricing before 1931 while unanticipated illiquidity mattered more from January 1931 onward. One explanation for this finding lies in the changing behavior of the autoregressive process for illiquidity. As discussed above, illiquidity was less predictable in the second half of the sample (i.e., the adjusted $R^2$ from the autoregressive model was 0.61 for 1928-1930 and only 0.23 for 1931-1933) and more likely the byproduct of liquidity black holes. In an environment where illiquidity is less predictable, its anticipated component should have less impact on bond prices.

To further explore the relationship between bond returns and illiquidity, we introduce macroeconomic shocks into the models. If illiquidity was driven solely by macroeconomic disturbances, inclusion of these shocks into the model should cause the explanatory power of the bid/ask spreads to fall significantly. If, on the other hand, illiquidity takes on a life of its own like a tropical storm (i.e., it is arises from unstable dynamics between price changes and order flow...
characteristic of liquidity black holes), adding macroeconomic shocks to the model should not cause the explanatory power of the spreads to diminish a great deal.

The macroeconomic shocks we include are:

\[ \Delta \text{DISCOUNT} = \text{monthly change in the New York Federal Reserve Bank rediscount rate}, \]
\[ \Delta (\text{DEPOSIT/RESERVE}) = \text{monthly change in the banking system deposit-reserve ratio}, \]
\[ \text{OCTOBER1929} = \text{dummy variable for October 1929} \]
\[ \text{MARCH1933} = \text{dummy variable for March 1933} \]

The first variable controls for the impact of monetary policy changes on bond returns. Unexpected increases in the discount rate should lead to lower government bond prices and realized returns. The second variable measures the impact of bank panics. To the extent that banks sold government bonds to meet panicky depositor demands for cash, a decrease in the Deposit/Reserve ratio should be associated with a fall in bond prices and realized returns. If there was a flight to safety during the October 1929 stock market crash, OCTOBER1929 should be positively related to realized government bond returns. The coefficient on MARCH1933 should be positive if, as is generally believed, the bank holiday during that month quelled panic and the flight to liquidity. In addition to these variables, we also include month dummies to control for seasonal effects. We found that all month dummies except January were insignificant and thus dropped them from the regressions.

Table 7 shows results for regressions that include the macroeconomic shocks. Overall, the regressions explain much more of the variation in bond returns than those in Table 4. For instance, the adjusted $R^2$ for the market return model in Table 7 is 0.46 compared to 0.35 in Table 4. The differences in explanatory power are largest for the long-term bonds, with adjusted $R^2$s approximately twice as large in the Table 7. These findings suggest that macro shocks help explain government bond returns.
Turning to the individual variables, the coefficient on OCTOBER1929 in the first column suggests that the market return was 2.30 percentage points higher in this month than the rest of the sample. Thus it appears that the stock market crash produced a flight to quality and liquidity that influenced bond returns. Interestingly, the effect was not equal across the bonds. Note that the size of the coefficient on OCTOBER1929 rises with bond maturity, as expected, but that the coefficient of 4.06 for the Treasury of 1944-54 is unusually high. As we saw above, this bond had a much larger volume outstanding and lower average spread than the other long-term bonds. Thus there is evidence that money fleeing the stock market flowed disproportionately into the more liquid sectors of the government bond market.

Returns were also significantly higher in March 1933, although the effect was not as strong as it was for the stock market crash. These results suggest that the March bank holiday restored confidence in financial markets and increased government bond returns.

Turning attention to monetary policy, we find that changes in the discount rate have the expected (negative) impact on realized bond returns, but the statistical significance is relatively low in all nine models. Moreover, there does not appear to be much difference in the coefficient on $\Delta$DISCOUNT across bonds. One possible reason for the modest effect of the discount rate is that it changed so infrequently. When it is replaced by monthly changes in the renewal rate on call loans, we obtain similar findings.

The coefficients on monthly changes in the deposit-reserve ratio also have the expected positive sign (i.e., bank attempts to hold more reserves are associated with lower realized bond returns), but they are generally not significant at the five percent level of confidence. However, the two most illiquid in our sample – the Treasury of 1940-43 and Treasury of 1943-47 – have the largest coefficients and t-statistics. This finding is consistent with the hypothesis that “fire sales” by banks during the panics had a larger impact on the prices of these two bonds either because they a) were sold, due to their relative illiquidity, in greater quantities or b) were sold into thinner markets.
Finally, the most important finding to emerge from Table 7 is that the illiquidity variables continue to explain bond returns even after controlling for macroeconomic shocks. In fact, we observe little change in the coefficients and t-statistics on ILLIQ_{t-1} and ILLIQ^U, in Table 7 when compared to Table 4. While the coefficients on lagged illiquidity are insignificant in Table 7, as was the case in Table 4, unexpected illiquidity continues to have a negative and highly significant impact on returns. The coefficient on ILLIQ^U in the first column suggests that a $0.10 rise in unexpected illiquidity is associated with a 2.82 percentage point decline in the monthly market return—a large decrease for bonds with zero default risk, traded in relatively liquid markets. Moreover, returns of the relatively more illiquid bonds continue to display greater sensitivity to marketwide illiquidity.

Overall, these findings support the hypothesis that liquidity was priced. Although we have not controlled for all possible macroeconomic shocks driving returns, the fact that the explanatory power of the bid/ask spreads diminishes little as we include more variables suggests that there was independent information contained in the bid/ask spreads that explain bond returns. This finding is consistent with the hypothesis that government bond markets periodically entered liquidity black holes where illiquidity took on a life of its own.

5. Conclusion

A large literature has developed over the past four decades to explore the causes and consequences of the U.S. banking system collapse during the Great Depression (see Calomiris and Mason (2003) for an excellent overview). In contrast, little research has explored the stability of the market making sector and its role in the bond market collapse of the 1930s, despite recent theoretical progress in this area. For instance, Morris and Shin (2004) and Bernardo and Welch (2004) show how behavior analogous to a bank run can occur in security markets due to the limited absorption capacity of market makers. In these models, marketwide liquidity disappears periodically and these “liquidity black holes” cause security prices to collapse.
This paper provides evidence that liquidity black holes were present in United States government bond markets during the Great Depression. We document dramatic fluctuations in government bond market illiquidity during the 1930s and, while illiquidity was associated with changes in monetary policy, bank runs, and other macroeconomic disturbances, cross-sectional evidence suggest that it periodically took on a life of its own. For example, bid/ask spreads on more liquid government bonds increased temporarily after Britain left the gold standard and the Federal Reserve raised interest rates in late 1931, while spreads on smaller and less liquid issues (but with the same fundamentals) remained elevated for months. We also provide evidence that marketwide liquidity risk was priced and that the empirical relationship between bond returns and illiquidity continues to hold after controlling for macroeconomic shocks. Overall, these results suggest that illiquidity played an important role in U.S. government bond markets during the Great Depression.
References


Temin, Peter, *Did Monetary Forces Cause the Great Depression?* New York: W.W. Norton, 1976.


Figure 3
Difference Between Quoted & Effective Spread

Figure 4
Marketwide Quoted Spread & Rediscount Rate
Figure 5
Marketwide Quoted Spread & Call Rate

Figure 6
Marketwide Quoted Spread & Deposit-Reserve Ratio
Figure 7
Marketwide Quoted Spread and Return
Table 1

Government Bond Characteristics

<table>
<thead>
<tr>
<th>Security</th>
<th>Date of Issue</th>
<th>Amount Issued</th>
<th>Call Date</th>
<th>Actual Call Date</th>
<th>Outstanding at Actual Call</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Liberty 3 1/2 of 1932-47</td>
<td>June 15, 1917</td>
<td>$1,989,455,550</td>
<td>June 15, 1932</td>
<td>June 15, 1935</td>
<td>$1,392,226,250</td>
</tr>
<tr>
<td>First Liberty Converted 4 1/4 of 1932-47</td>
<td>May 9, 1918</td>
<td>555,125,600</td>
<td>June 15, 1932</td>
<td>June 15, 1935</td>
<td>532,489,100</td>
</tr>
<tr>
<td>Fourth Liberty 4 1/4 of 1933-38</td>
<td>Oct. 24, 1918</td>
<td>6,964,581,100</td>
<td>Oct. 15, 1933</td>
<td>April 15, 1934</td>
<td>6,268,000,000</td>
</tr>
<tr>
<td>Treasury 3 3/8 of 1940-43</td>
<td>July 16, 1928</td>
<td>359,042,950</td>
<td>June 15, 1940</td>
<td>June 15, 1940</td>
<td>353,000,000</td>
</tr>
<tr>
<td>Treasury 3 3/8 of 1943-47</td>
<td>June 15, 1927</td>
<td>494,854,750</td>
<td>June 15, 1943</td>
<td>June 15, 1943</td>
<td>454,000,000</td>
</tr>
<tr>
<td>Treasury 4 of 1944-54</td>
<td>Dec. 15, 1929</td>
<td>1,947,080,500</td>
<td>Dec. 15, 1944</td>
<td>Dec. 15, 1944</td>
<td>1,036,692,900</td>
</tr>
<tr>
<td>Treasury 3 3/4 of 1946-58</td>
<td>Mar. 15, 1926</td>
<td>494,898,100</td>
<td>Mar. 15, 1946</td>
<td>Mar. 15, 1946</td>
<td>489,000,000</td>
</tr>
</tbody>
</table>

### Table 2

**Government Bond Illiquidity Variables: 1928-1933 (Inclusive)**

<table>
<thead>
<tr>
<th>Security</th>
<th>Quoted Bid-Ask Spread ($)</th>
<th>Effective Bid-Ask Spread ($)</th>
<th>Trading Volume ($1,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Variance</td>
<td>Mean</td>
</tr>
<tr>
<td>First Liberty 3 1/2 of 1932-47</td>
<td>0.0958</td>
<td>0.0041</td>
<td>0.0880</td>
</tr>
<tr>
<td>First Liberty Converted 4 1/4 of 1932-47</td>
<td>0.1060</td>
<td>0.0058</td>
<td>0.0847</td>
</tr>
<tr>
<td>Fourth Liberty 4 1/4 of 1933-38</td>
<td>0.0678</td>
<td>0.0014</td>
<td>0.0552</td>
</tr>
<tr>
<td>Treasury 3 3/8 of 1940-43</td>
<td>0.1496</td>
<td>0.0158</td>
<td>0.1543</td>
</tr>
<tr>
<td>Treasury 3 3/8 of 1943-47</td>
<td>0.1638</td>
<td>0.0202</td>
<td>0.1610</td>
</tr>
<tr>
<td>Treasury 4 of 1944-54</td>
<td>0.1557</td>
<td>0.0124</td>
<td>0.1287</td>
</tr>
<tr>
<td>Treasury 3 3/4 of 1946-56</td>
<td>0.1608</td>
<td>0.0194</td>
<td>0.1416</td>
</tr>
<tr>
<td>Treasury 4 1/4 of 1947-52</td>
<td>0.1518</td>
<td>0.0151</td>
<td>0.1416</td>
</tr>
</tbody>
</table>

Source: Author's calculation based on data from the *New York Times* table, "Bond Sales on the Stock Exchange." Markets were open and quotes posted on 1,612 days. The number of days transactions were recorded ranges from 1,612 for the Fourth Liberty 4 1/4 of 1933-38 to 1,240 for the Treasury 3 3/4 of 1946-56. Highest and lowest values given in bold.
### Table 3

Quoted Bid-Ask Spread Correlations: 1928-1933 (Inclusive)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
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<tbody>
<tr>
<td>First Liberty 1932-47</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Lib. Conv. 1932-47</td>
<td>0.338</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fourth Liberty 1933-38</td>
<td>0.175</td>
<td>0.196</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treasury 1940-43</td>
<td>0.259</td>
<td>0.221</td>
<td>0.126</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Treasury 1943-47</td>
<td>0.205</td>
<td>0.378</td>
<td>0.157</td>
<td>0.594</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treasury 1944-54</td>
<td>0.257</td>
<td>0.272</td>
<td>0.207</td>
<td>0.333</td>
<td>0.308</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treasury 1945-56</td>
<td>0.272</td>
<td>0.343</td>
<td>0.158</td>
<td>0.408</td>
<td>0.472</td>
<td>0.477</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treasury 1947-52</td>
<td>0.255</td>
<td>0.343</td>
<td>0.160</td>
<td>0.315</td>
<td>0.397</td>
<td>0.433</td>
<td>0.392</td>
<td>0.360</td>
<td>0.230</td>
</tr>
</tbody>
</table>

**Average**

0.262 0.212 0.169 0.343 0.257 0.326 0.360 0.230

**Source:** Author's calculation based on data from the New York Times' table, "Bond Sales on the Stock Exchange." The last row shows the average correlation between the spread of the bond listed at the top of the column and spreads of the other seven bonds.
Table 4
The Effect of Market Illiquidity on Bond Returns

Estimation Period: 1928:1-1933:12

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>constant</th>
<th>ILLIQ&lt;sub&gt;0-5&lt;/sub&gt;</th>
<th>ILLIQ&lt;sub&gt;n&lt;/sub&gt;</th>
<th>R&lt;sup&gt;2&lt;/sup&gt;</th>
<th>D-W</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&lt;sub&gt;1k&lt;/sub&gt; (The Market)</td>
<td>-0.13</td>
<td>3.27</td>
<td>-23.05</td>
<td>(7.42)**</td>
<td>0.35</td>
</tr>
<tr>
<td>R&lt;sub&gt;1k&lt;/sub&gt; (1st Liberty of 1932-47)</td>
<td>-0.06</td>
<td>2.73</td>
<td>-21.53</td>
<td>(6.15)**</td>
<td>0.36</td>
</tr>
<tr>
<td>R&lt;sub&gt;1k&lt;/sub&gt; (1st Lib. Con. of 1932-47)</td>
<td>0.21</td>
<td>0.99</td>
<td>-8.86</td>
<td>(4.23)**</td>
<td>0.16</td>
</tr>
<tr>
<td>R&lt;sub&gt;1k&lt;/sub&gt; (4th Liberty of 1933-38)</td>
<td>0.07</td>
<td>2.00</td>
<td>-11.97</td>
<td>(5.93)**</td>
<td>0.28</td>
</tr>
<tr>
<td>R&lt;sub&gt;40&lt;/sub&gt; (Treasury of 1940-43)</td>
<td>-0.09</td>
<td>3.02</td>
<td>-24.84</td>
<td>(6.53)**</td>
<td>0.30</td>
</tr>
<tr>
<td>R&lt;sub&gt;43&lt;/sub&gt; (Treasury of 1943-47)</td>
<td>-0.14</td>
<td>3.13</td>
<td>-27.17</td>
<td>(6.34)**</td>
<td>0.30</td>
</tr>
<tr>
<td>R&lt;sub&gt;44&lt;/sub&gt; (Treasury of 1944-54)</td>
<td>-0.37</td>
<td>4.93</td>
<td>-27.60</td>
<td>(6.15)**</td>
<td>0.30</td>
</tr>
<tr>
<td>R&lt;sub&gt;46&lt;/sub&gt; (Treasury of 1946-56)</td>
<td>-0.33</td>
<td>4.62</td>
<td>-30.12</td>
<td>(5.76)**</td>
<td>0.28</td>
</tr>
<tr>
<td>R&lt;sub&gt;52&lt;/sub&gt; (Treasury of 1947-52)</td>
<td>-0.33</td>
<td>4.53</td>
<td>-31.96</td>
<td>(7.37)**</td>
<td>0.38</td>
</tr>
</tbody>
</table>

Note: the dependent variable is the monthly return for an equally-weighted portfolio of government bonds (R<sub>1k</sub>) or one of the eight individual government bonds, R<sub>4i</sub>. The explanatory variables are lagged market illiquidity, ILLIQ<sub>0-5</sub>, the average across bonds of daily quoted bid-ask spreads (averaged over the month), and unexpected market illiquidity, ILLIQ<sub>n</sub>, the residual from an autoregressive model fit to ILLIQ<sub>1k</sub>. The t-statistics are calculated from standard errors corrected for heteroskedasticity and autocorrelation using the Newey-West method.

Statistical significance at the 0.05 and 0.01 level denoted by * and ** respectively.
### Table 5
The Effect of Market Illiquidity on Bond Returns: 1928-1930

Estimation Period: 1928-1:1930:12

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>constant</th>
<th>ILLIQ(_{n-3})</th>
<th>ILLIQ(^{II})(_{n-3})</th>
<th>(R^2)</th>
<th>D-W</th>
</tr>
</thead>
<tbody>
<tr>
<td>(R_{mt}) (The Market)</td>
<td>-0.39</td>
<td>5.44</td>
<td>-23.05</td>
<td>0.21</td>
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<td>(1.43)</td>
<td>(2.02)*</td>
<td>(7.42)**</td>
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<tr>
<td>(R_{1st}) (1st Liberty of 1932-47)</td>
<td>0.16</td>
<td>1.22</td>
<td>-10.59</td>
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<td></td>
<td>(0.71)</td>
<td>(0.58)</td>
<td>(2.34)*</td>
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<tr>
<td>(R_{2nd}) (1st Lib. Con. of 1932-47)</td>
<td>-0.02</td>
<td>2.96</td>
<td>-9.54</td>
<td>0.17</td>
<td>1.91</td>
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<td>(0.10)</td>
<td>(1.52)</td>
<td>(3.25)**</td>
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<tr>
<td>(R_{3rd}) (4th Liberty of 1933-38)</td>
<td>-0.07</td>
<td>3.30</td>
<td>-10.20</td>
<td>0.16</td>
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<td>(0.27)</td>
<td>(1.54)</td>
<td>(3.82)**</td>
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<tr>
<td>(R_{4th}) (Treasury of 1940-43)</td>
<td>-0.19</td>
<td>4.35</td>
<td>-11.52</td>
<td>0.09</td>
<td>2.59</td>
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<td>(0.67)</td>
<td>(2.04)*</td>
<td>(2.01)*</td>
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<tr>
<td>(R_{5th}) (Treasury of 1943-47)</td>
<td>-0.45</td>
<td>5.83</td>
<td>-17.72</td>
<td>0.23</td>
<td>2.25</td>
</tr>
<tr>
<td></td>
<td>(1.32)</td>
<td>(1.91)**</td>
<td>(2.51)**</td>
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<tr>
<td>(R_{6th}) (Treasury of 1944-54)</td>
<td>-0.81</td>
<td>8.41</td>
<td>-19.63</td>
<td>0.14</td>
<td>2.11</td>
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<td>(1.70)</td>
<td>(1.87)</td>
<td>(3.26)**</td>
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<td>(R_{7th}) (Treasury of 1946-56)</td>
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<td>-16.85</td>
<td>0.12</td>
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<td>(1.46)</td>
<td>(1.79)</td>
<td>(3.89)**</td>
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<tr>
<td>(R_{8th}) (Treasury of 1947-52)</td>
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<td>-26.68</td>
<td>0.27</td>
<td>2.16</td>
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<td></td>
<td>(2.52)**</td>
<td>(2.29)*</td>
<td>(5.14)***</td>
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</tbody>
</table>

Note: the dependent variable is the monthly return for an equally-weighted portfolio of government bonds \(R_{mt}\) or one of the eight individual government bonds \(R_{1st}\). The explanatory variables are lagged market illiquidity, ILLIQ\(_{n-3}\), the average across bonds of daily quoted bid-ask spreads (averaged over the month), and unexpected market illiquidity, ILLIQ\(^{II}\)\(_{n-3}\), the residual from an autoregressive model fit to ILLIQ\(_{n-3}\). The t-statistics are calculated from standard errors corrected for heteroskedasticity and autocorrelation using the Newey-West method.

Statistical significance at the 0.05 and 0.01 level denoted by * and ** respectively.
**Table 6**

The Effect of Market Illiquidity on Bond Returns: 1931-1933

**Estimation Period:** 1931:01-1933:12

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>constant</th>
<th>ILLIQ_{t-1}</th>
<th>ILLIQ^II_{t-1}</th>
<th>R^2</th>
<th>D-W</th>
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<tbody>
<tr>
<td>R_{mt} (The Market)</td>
<td>0.29</td>
<td>-0.82</td>
<td>-27.74***</td>
<td>0.41</td>
<td>2.56</td>
</tr>
<tr>
<td>(0.51)</td>
<td>(0.14)</td>
<td>(6.31)**</td>
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<td></td>
<td></td>
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<tr>
<td>R_{1st} (1st Liberty of 1932-47)</td>
<td>-0.01</td>
<td>1.81</td>
<td>-26.66***</td>
<td>0.45</td>
<td>2.36</td>
</tr>
<tr>
<td>(0.01)</td>
<td>(0.41)</td>
<td>(6.92)**</td>
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<td></td>
</tr>
<tr>
<td>R_{2nd} (1st Lib. Con. of 1932-47)</td>
<td>0.43</td>
<td>-1.20</td>
<td>-9.43***</td>
<td>0.15</td>
<td>2.42</td>
</tr>
<tr>
<td>(1.31)</td>
<td>(0.40)</td>
<td>(3.48)**</td>
<td></td>
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<td></td>
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<tr>
<td>R_{3rd} (4th Liberty of 1933-38)</td>
<td>0.27</td>
<td>-0.03</td>
<td>-13.54***</td>
<td>0.34</td>
<td>2.07</td>
</tr>
<tr>
<td>(0.67)</td>
<td>(0.00)</td>
<td>(5.47)**</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>R_{4th} (Treasury of 1940-43)</td>
<td>0.37</td>
<td>-1.73</td>
<td>-31.55***</td>
<td>0.37</td>
<td>2.56</td>
</tr>
<tr>
<td>(0.57)</td>
<td>(0.26)</td>
<td>(5.96)**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_{5th} (Treasury of 1943-47)</td>
<td>0.39</td>
<td>-2.03</td>
<td>-33.21***</td>
<td>0.33</td>
<td>2.39</td>
</tr>
<tr>
<td>(0.53)</td>
<td>(0.26)</td>
<td>(5.28)**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_{6th} (Treasury of 1944-54)</td>
<td>0.21</td>
<td>-0.53</td>
<td>-33.05***</td>
<td>0.38</td>
<td>2.82</td>
</tr>
<tr>
<td>(0.32)</td>
<td>(0.09)</td>
<td>(5.79)**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_{7th} (Treasury of 1946-56)</td>
<td>0.24</td>
<td>-0.83</td>
<td>-37.87***</td>
<td>0.33</td>
<td>2.76</td>
</tr>
<tr>
<td>(0.28)</td>
<td>(0.10)</td>
<td>(5.08)**</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>R_{8th} (Treasury of 1947-52)</td>
<td>0.37</td>
<td>-1.96</td>
<td>-36.64***</td>
<td>0.45</td>
<td>2.73</td>
</tr>
<tr>
<td>(0.50)</td>
<td>(0.32)</td>
<td>(6.39)**</td>
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</tbody>
</table>

Note: the dependent variable is the monthly return for an equally-weighted portfolio of government bonds (R_{mt}) or one of the eight individual government bonds, R_{it}. The explanatory variables are lagged market illiquidity, ILLIQ_{t-1}, the average across bonds of daily quoted bid-ask spreads (averaged over the month), and unexpected market illiquidity, ILLIQ^II_{t-1}, the residual from an autoregressive model fit to ILLIQ_{mt}. The t-statistics are calculated from standard errors corrected for heteroskedasticity and autocorrelation using the Newey-West method.

Statistical significance at the 0.05 and 0.01 level denoted by * and ** respectively.
### Table 7

The Effect of Market Illiquidity and Macro Shocks on Bond Returns

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The Market</td>
<td>$R_{M,t}$</td>
<td>$R_{12t}$</td>
<td>$R_{25t}$</td>
</tr>
<tr>
<td>Constant</td>
<td>0.21</td>
<td>0.04</td>
<td>0.28</td>
<td>0.25</td>
</tr>
<tr>
<td>ILLIQ$^{u}_{m,t-1}$</td>
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<td>0.37</td>
<td>0.72</td>
</tr>
<tr>
<td>ILLIQ$^{l}_{m,t}$</td>
<td>-20.82 ***</td>
<td>-18.37 ***</td>
<td>-7.06 ***</td>
<td>-9.52 ***</td>
</tr>
<tr>
<td>JANUARY</td>
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<td>-0.98</td>
<td>-0.38</td>
<td>-0.28</td>
</tr>
<tr>
<td>OCTOBER1929</td>
<td>2.30</td>
<td>0.24</td>
<td>1.01</td>
<td>1.00</td>
</tr>
<tr>
<td>MARCH1933</td>
<td>1.71</td>
<td>0.42</td>
<td>0.80</td>
<td>0.83</td>
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<tr>
<td>∆[DEPOSIT/RESERVE]</td>
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<td>0.16</td>
<td>0.06</td>
<td>0.40</td>
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<td>∆DISCOUNT</td>
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<td>-0.63</td>
<td>-0.39</td>
<td>-0.53</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.46</td>
<td>0.42</td>
<td>0.22</td>
<td>0.38</td>
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</table>

Note: the dependent variable is the monthly return for an equally-weighted portfolio of government bonds ($R_{M,t}$) or one of the eight individual government bonds, $R_{it}$. The explanatory variables are lagged market illiquidity, ILLIQ$^{u}_{m,t-1}$, the average across bonds of daily quoted bid-ask spreads (averaged over the month), and unexpected market illiquidity, ILLIQ$^{l}_{m,t}$; the residual from an autoregressive model fit to ILLIQ$^{u}_{m,t}$; dummy variables for January (JANUARY), the stock market crash (OCTOBER1929), the bank holiday (MARCH1933); first-difference in the bank deposit-reserve ratio (∆[DEPOSIT/RESERVE]); and first-difference in the Federal Reserve rediscount rate (∆DISCOUNT). The t-statistics are calculated from standard errors corrected for heteroskedasticity and autocorrelation using the Newey-West method.

Statistical significance at the 0.05 and 0.01 level denoted by * and ** respectively.
**Table 7 continued**

The Effect of Market Illiquidity and Macroe Shocks on Bond Returns

<table>
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<tbody>
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<td><strong>Explanatory Variables:</strong></td>
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<td>( R_{it} )</td>
<td>( R_{it} )</td>
<td>( R_{it} )</td>
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<tr>
<td>Constant</td>
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<td>0.41</td>
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<td>0.23</td>
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</tr>
<tr>
<td>(0.95)</td>
<td>(0.76)</td>
<td>(0.01)</td>
<td>(0.38)</td>
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<td>ILLIQ_{it-1}</td>
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<td>2.09</td>
<td>0.62</td>
<td>1.06</td>
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<td>-29.73</td>
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<tr>
<td>(6.06)**</td>
<td>(6.09)**</td>
<td>(4.79)**</td>
<td>(4.72)**</td>
<td>(5.36)**</td>
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</tr>
<tr>
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<td>-0.76</td>
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<td>-1.32</td>
<td>-0.77</td>
</tr>
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<td>(1.70)</td>
<td>(2.35)*</td>
<td>(1.79)</td>
<td>(1.47)</td>
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</tr>
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<td>4.06</td>
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<td>4.09</td>
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<tr>
<td>(5.51)**</td>
<td>(4.38)**</td>
<td>(16.60)**</td>
<td>(9.84)**</td>
<td>(16.41)**</td>
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<tr>
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<td>2.51</td>
<td>3.29</td>
<td>2.78</td>
</tr>
<tr>
<td>(3.57)**</td>
<td>(3.73)**</td>
<td>(6.93)**</td>
<td>(7.89)**</td>
<td>(7.31)**</td>
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<tr>
<td>ΔDEPOSIT/RESERVE__i</td>
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<td>1.34</td>
<td>0.45</td>
<td>0.92</td>
<td>0.67</td>
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<tr>
<td>(2.17)**</td>
<td>(1.89)</td>
<td>(1.05)</td>
<td>(1.94)</td>
<td>(1.42)</td>
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<tr>
<td>ΔDISCOUNT__i</td>
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<td>-0.56</td>
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<td>-0.70</td>
<td>-0.66</td>
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<tr>
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<td>(1.54)</td>
<td>(1.66)</td>
<td>(1.62)</td>
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<tr>
<td>( R^2 )</td>
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<td>0.45</td>
<td>0.40</td>
<td>0.51</td>
</tr>
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<td>D-W</td>
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<td>2.19</td>
<td>2.54</td>
<td>2.48</td>
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</table>

Note: the dependent variable is the monthly return for an equally-weighted portfolio of government bonds (\( R_{it} \)) or one of the eight individual government bonds, \( R_{it} \). The explanatory variables are lagged market illiquidity, ILLIQ_{it-1}, the average across bonds of daily quoted bid-ask spreads (averaged over the month), and unexpected market illiquidity, ILLIQ_{it}, the residual from an autoregressive model fit to ILLIQ_{it-1}, dummy variables for January (JANUARY), the stock market crash (OCTOBER1929), the bank holiday (MARCH1933), first-difference in the bank deposit-reserve ratio (ΔDEPOSIT/RESERVE_\_i), and first-difference in the Federal Reserve rediscount rate (ΔDISCOUNT_\_i). The t-statistics are calculated from standard errors corrected for heteroskedasticity and autocorrelation using the Newey-West method.

Statistical significance at the 0.05 and 0.01 level denoted by * and ***, respectively.