ANNUAL REVIEW OF FINANCIAL ECONOMICS (/content/journals/financial) **Volume 9, 2017** (/content/journals/financial/9/1)

Market Liquidity After the Financial Crisis

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Vol. 9:43-83 (Volume publication date November 2017)

ABSTRACT

This article examines market liquidity in the postcrisis era in light of concerns that regulatory changes might have reduced dealers' ability and willingness to
an overview of regulations and their potential effects on dealer balance sheets and market making, but also considering additional drivers of market liquidi
which occurred concurrently with dealer balance sheet deleveraging. However, using high-frequency trade and quote data for US Treasuries and corporate

Keywords

liquidity (/search?option1=pub_keyword&value1="liquidity"), **market making (/search?option1=pub_keyword&value1="market making")**, **regulation (/search?option1
option1=pub_keyword&value1="Treasury securities")**, **corporate bonds (/search?option1=pub_keyword&value1="corporate bonds")**

1. INTRODUCTION

In the years since the financial crisis of 2007–2009, market participants have expressed concerns about worsening liquidity in certain markets (for media rep
Marriage & Mooney 2016). Market liquidity, broadly defined, refers to the cost of exchanging assets for cash. Liquidity considerations feature prominently i
demanding higher returns for less liquid assets (**Amihud & Mendelson 1986**). Moreover, asset illiquidity deters trade and hence investment, impeding the e

Frequently cited causes for the ostensibly worsening liquidity are the Dodd–Frank Act and the Basel III regulatory framework. In an effort to address the solv
provisions that tighten banks' capital requirements, introduce leverage ratios, and establish liquidity requirements. Although these regulations are intende
that they also increase the cost of market making by raising the cost of capital and restricting dealers' risk taking. The differing perspectives of regulators an
capital and liquidity buffers to maintain its market-making functions in times of stress but potentially provides less liquidity in normal times.

This article examines the evidence surrounding market liquidity in the postcrisis era. We begin with a discussion of the broader trading environment in an e
of regulations and their potential effects on dealer balance sheets and market making, as well as other plausible determinants of market liquidity. The drive

1. the postcrisis regulatory framework, reflecting the Dodd–Frank Act and the Basel III capital and liquidity requirements;
2. voluntary changes in dealer risk-management practices and balance sheet composition following the housing market boom and bust;
3. changes in market structure with the growth of electronic trading;
4. the changing landscape of institutional investors, including the evolving liquidity demands of large asset managers; and
5. changes in expected returns associated with the economic environment.

We argue that because these factors were all at play in the years immediately following the crisis, identification of the causal effects of any single factor mus
of these drivers are highly interrelated and endogenous.

We document the striking fact that dealer balance sheets stagnated after the crisis. In the years running up to the crisis, dealer assets grew at an exponentia
$3.5 trillion, a level that was first breached in 2005. After that, through mid-2016, dealer assets were stagnant around this $3.5 trillion level. This balance she
intended consequence of tighter capital regulation. However, the stagnation and deleveraging of dealer balance sheets raises the questions of whether regu
in dealer-intermediated markets can still be provided efficiently. To get at this question, we analyze market liquidity empirically.

Our main empirical exercise consists of assessing the evolution of market liquidity in the US Treasury and US corporate bond markets. Market participants' c
these are the most important of these markets. Given the multifaceted nature of market liquidity, we compute a variety of liquidity measures, including bid-
book and transactions data from the interdealer Treasury market and on corporate bond transactions data from the Trade Reporting and Compliance Engin

Overall, we do not find strong quantitative evidence of a widespread deterioration in bond market liquidity in the years after the crisis. As of mid-2016, avera
stable. Moreover, Treasury market depth and price impact, though suggesting reduced liquidity, were within historical variation and far from crisis levels. Fo
to levels higher than those before the crisis for institutional trades (i.e., trades of $100,000 and above). Moreover, corporate bond trading volume and issuar

Our empirical findings on market liquidity are broadly consistent with those of others. Analyzing TRACE corporate bond transactions data from 2003 to 2015
transaction volumes, narrowing bid-ask spreads, and falling price impact of trades. Looking at price impact, round-trip costs, and other measures, **Trebbi &**
liquidity levels or breaks in liquidity risk for corporate bonds." **Bessembinder et al. (2016)** further find lower transaction costs during the 2012–2014 Dodd–
report lower average transaction costs and price impact postcrisis versus precrisis for all corporate bond transactions, but also report somewhat worse liqu

In contrast to these studies on broad liquidity trends, several studies have documented worsening liquidity along some dimension. **Bao, O'Hara & Zhou (20**
comparing the periods before and after implementation of the Volcker rule. Similarly, **Dick-Nielsen & Rossi (2016)** use bond index exclusions as a natural ex
authors find that the price of immediacy significantly increased postcrisis versus precrisis. **Choi & Huh (2016)** show that dealers are providing liquidity for a
subset of trades. Furthermore, although **Bessembinder et al. (2016)** estimate lower transaction costs after the crisis, they also document a structural break
Adrian, Boyarchenko & Shachar (2017) find that corporate bond liquidity provision declined significantly in recent years for dealers that are relatively mor

We also present three case studies on the resilience of market liquidity to shocks in the postcrisis era. The first analyzes dealer balance sheet behavior durin
10-week period. The second looks at the October 2014 flash rally in the US Treasury market, when yields rose and fell rapidly within a 12-minute event wind
fund in December 2015 affected market liquidity. In all three cases, the degree of deterioration in market liquidity was within historical norms, suggesting th

Although we do not uncover clear indications of a widespread worsening of bond market liquidity, our analysis faces several limitations. Most importantly, o
account for any trades that have not taken place due to changes in the regulatory environment or other factors. Future work should thus consider both a wi
Moreover, dealer balance sheets have undergone dramatic changes, reflecting macroeconomic trends and the evolution of the market-making business mo
swap (CDS)-bond basis, imply increased balance sheet costs. Further researching the determinants of these funding cost metrics is a promising avenue of fu
liquidity (**Brunnermeier & Pedersen 2009**). Additional topics for future research include endogeneities in the data-generating process and the concept of li

This article proceeds as follows. Section 2 discusses the evolving trading environment for broker/dealers as well as the broader trading environment. Sectio
literature. Section 4 discusses directions for future research, and Section 5 concludes.

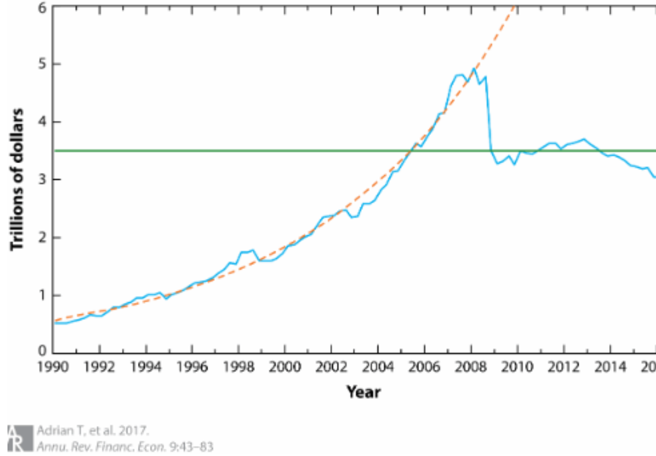
2. THE POSTCRISIS TRADING ENVIRONMENT

Security broker/dealers (or simply dealers) trade securities on behalf of their customers and for their own accounts, using their balance sheets primarily for
rapidly in recent years, as we illustrate through dealer balance sheet size. A priori, we would expect the size of dealers' balance sheets to expand exponentia

Figure 1 shows dealer balance sheet size from 1990 to 2016. Dealer size grew exponentially from 1990 through 2008, with a peak close to $5 trillion. Dealer a
trillion, the level of 2005. If the previous trend of exponential growth had continued, the balance sheet size of dealers would have been several times larger i
the questions of whether the $5 trillion peak was excessive, whether the precrisis growth was sustainable, and whether the 2016 level was, in some sense, d
be constrained, adversely affecting market liquidity (**Adrian et al. 2015g)**.

Figure 1

Dealers' assets. This figure plots the total financial assets of security broker/dealers at the subsidiary level. The orange dashed curve shows the computed exponential growth trend of the 1990–2008 per
Board of Governors of the Federal Reserve System.



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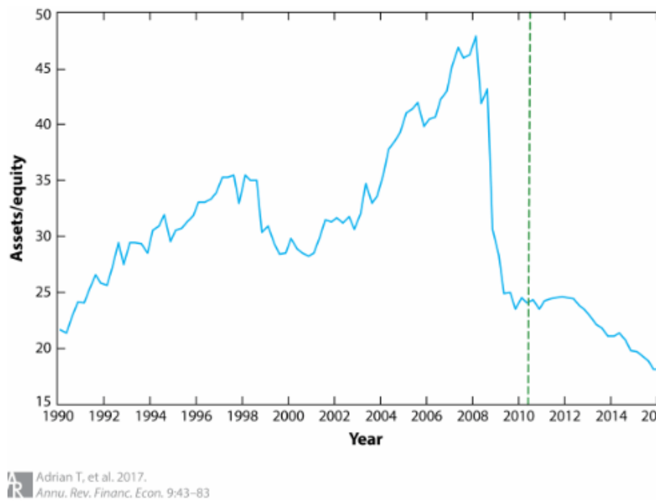
One possible explanation for the stagnation of the balance sheet size of dealers is regulation. In fact, tighter capital regulation explicitly seeks to limit balan reduction in assets. However, the extent to which the stagnation of dealer balance sheet size has been caused by regulation is difficult to quantify because o normal course of business. Recent research (**Adrian & Shin 2014**) suggests that dealers expand their balance sheets in booms and contract them in busts, p correlated, because (other things being equal) higher leverage mechanically exposes dealers to more risk by amplifying potential losses. It is therefore not u potential losses are realized.

Figure 2 shows that the private incentives of dealers to deleverage and the social incentives of regulators to impose limits on leverage coincided in the wake just prior to the near failure of Bear Stearns, but then dropped to 25 by June 2009, roughly a year before the passage of Dodd–Frank and the announcement prior to the announcement of potentially constraining regulation. Dodd–Frank and Basel III regulations may help explain the deleveraging since 2010, but it today.

Figure 2

Procyclical dealer leverage. This figure shows the leverage of security broker/dealers at the subsidiary level. Leverage is defined as (total assets)/(book equity capital). The green dotted line marks the pa Financial Accounts of the United States published by the Board of Governors of the Federal Reserve System.



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As mentioned, there are a number of possible explanations for the remarkable change in dealer balance sheets, including the postcrisis regulatory framewo the growth of electronic trading, the evolving liquidity demands of large asset managers, and changes in expected returns. We discuss each of these factors

2.1. Postcrisis Regulatory Framework

Regulations affecting the dealer sector tightened markedly after the financial crisis of 2007–2009. The five major independent US dealers were outside of th either failed (Lehman), were acquired by banking organizations (Bear Stearns and Merrill Lynch), or became bank-holding companies (BHCs) themselves (G Reserve's stress tests and enhanced capital and liquidity requirements, as well as the more stringent Basel III rules.

Regulatory reform after the crisis stems directly from shortcomings in the regulatory framework uncovered during the crisis. During the crisis, banks, dealer experienced both solvency and liquidity problems. That motivated subsequent tightening of capital and liquidity requirements. In addition, some regulatio trading by banks. The regulations have substantially affected institutions' business models. We briefly review these regulatory changes and provide further

2.1.1. Basel 2.5 market risk amendment.

In 2010, the Basel Committee on Banking Supervision (**BCBS 2010**) put forth the market risk amendment, recognizing that the existing capital framework fo framework was supplemented with an incremental risk capital charge that accounted for default and migration risk for credit products. The incremental risl trading books. In addition, this framework introduced a stressed VaR requirement. The incremental risk capital charge and the stressed VaR requirement sig derivatives [**Committee on the Global Financial System (CGFS) 2014**].

2.1.2. Basel III capital requirements.

The 2010 Basel III capital framework (**BCBS 2011**) aims to strengthen the resilience of the banking sector through enhanced capital requirements. The refor coverage of the capital framework. The BCBS also introduced several macroprudential elements into the capital framework to help contain systemic risk ari

In order to improve the quality of capital, Basel III requires the preponderance of tier 1 capital to be in the form of common shares and retained earnings. Co introduced a capital conservation buffer of 2.5% that can be drawn down in periods of stress. Furthermore, the committee introduced a countercyclical cap credit cycle.

Basel III introduced measures to strengthen the capital requirements for counterparty credit exposures arising from banks' derivatives, repurchase agreeme requirement for counterparty credit risk using stress assumptions in order to address concerns about capital charges becoming too low during periods of co leverage. Banks are subject to a capital charge for potential mark-to-market losses, referred to as a credit valuation adjustment, associated with a deteriorat

The BCBS also introduced a leverage ratio requirement to constrain leverage in the banking sector. The leverage ratio provides an additional safeguard agai with a simple, transparent, independent measure of risk. The leverage ratio requirement is 3%, with an additional 2% supplement for the largest US institut businesses such as market making in repo and highly rated sovereign bonds (**CGFS 2014**).

The BCBS additionally introduced a macroprudential surcharge to reduce the probability of failure of global systemically important banks (GSIBs) by increa improving global recovery and resolution frameworks (**BCBS 2013b**). The systemic importance of GSIBs is assessed using an indicator-based measurement generates negative externalities and what makes a bank critical for the stability of the financial system, and include size, cross-jurisdictional activity, interco

2.1.3. Liquidity regulation.

To bolster the liquidity positions of banks, the BCBS developed the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR; see **BCBS 2013a**, **20** profiles by ensuring that banks have an adequate stock of liquid assets to meet liquidity needs for a 30-day stress scenario. The objective of the NSFR is to re sufficiently stable sources of funding. The NSFR is defined as the amount of available stable funding relative to the amount of required stable funding and m

2.1.4. Total loss-absorbing capacity.

In 2013, G20 leaders asked regulators to assess and develop proposals to ensure the adequacy of global systemically important financial institutions' loss-a failure of GSIBs by requiring sufficient loss-absorbing and recapitalization capacity in resolution to implement an orderly resolution that minimizes effects c funds to loss. A total loss-absorbing capacity requirement thus imposes a minimum level of bail-in-able debt, which can be transformed into equity during t

2.1.5. Stress tests.

In the United States, the Federal Reserve conducts annual stress tests for the largest BHCs and designated systemically important financial institutions (SIFI sufficient capital to absorb losses resulting from adverse economic conditions. The tests are based on a hypothetical, severely adverse scenario designed by business activities of each BHC, and are estimated using a consistent approach across BHCs. The projected losses under the scenario thereby provide a unic comparable results across firms.

The Federal Reserve's annual Comprehensive Capital Analysis and Review (CCAR) is an intensive assessment of the capital adequacy and capital planning p seeks to ensure that large BHCs have strong processes for assessing their capital needs supported by effective firm-wide practices to identify, measure, and directors and senior management. CCAR helps promote greater resiliency at firms by requiring each BHC to support its capital management decisions with f profile and activities as well as the effect of highly stressful operating environments on financial performance.

2.1.6. Volcker rule.

Section 619 of the Dodd–Frank Act, referred to as the Volcker rule, prohibits insured depository institutions and any company affiliated with an insured depo ownership interests in, sponsoring, or having certain relationships with a hedge fund or private equity fund. The rule, aiming to rein in excessive risk taking i for market-making activities. Although the rule directly affects market makers' capacity to provide liquidity, **Duffie (2012)** argues that overall market liquidi hedge funds or insurance companies. US Treasuries, agency mortgage-backed securities (MBS), and agency debt securities are exempt from the Volcker rule

2.1.7. Impact of the regulatory reforms for dealers.

CGFS (2014) considers the effects of these regulations for dealers' business models and market making more generally. Regulatory changes after the crisis l raise market-making costs. Risk weights and credit risk charges make trading of corporate bonds and credit derivatives more expensive. In particular, the in Furthermore, less liquid corporate bonds are ineligible for the LCR, which is thought to reduce the willingness of banks to warehouse these assets. Moreove corporate bonds and structured credit, increasing dealers' financing costs.

CGFS (2016) provides results of an informal survey of market participants on the effects of regulatory reforms. Respondents provided estimates of the relati trading and operational costs, using two highly stylized portfolios: one of sovereign bonds and one of corporate bonds. The survey results suggest that the e leverage ratio and higher risk-weighted capital requirements are thought to have the largest effect on regulatory capital charges and, hence, on dealers' pro (Basel 2.5) are thought to have the largest effect on regulatory charges. The survey responses imply that the gross revenue required to yield a return on capi 20% under Basel II.

The academic evidence on the effects of regulatory reforms is mixed, at least partially reflecting the challenges in estimating effects of regulations considere As noted earlier, **Mizrach (2015)**, **Bessembinder et al. (2016)**, and **Anderson & Stulz (2017)** find that corporate bond liquidity overall is better in the postcr transaction costs and price impact for large (≥$100,000) trades, a finding that we discuss further below. **Trebbi & Xiao (2015)** test for break points in variou approval of Dodd–Frank, the occurrence of major bank proprietary trading desk closures, or the Volcker rule finalization, and conclude that postcrisis regula

In contrast, **Bao, O'Hara & Zhou (2016)** find that price impact increased among recently downgraded corporate bonds when comparing the periods before that the price of immediacy (which they measure around bond index inclusions) significantly increased postcrisis versus precrisis. Moreover, **Choi & Huh (2** that transaction costs have increased for this subset of trades. **Bessembinder et al. (2016)** also find that dealers' propensity to intermediate on an agency b capital on a principal basis in the postcrisis period. Although their study does not rule out other explanations, they note that the timing of these changes is c Frank.

Adrian, Boyarchenko & Shachar (2017) study the relationship between bond-level liquidity and financial institutions' balance sheet constraints. They first Bonds traded by more levered and systemic institutions (those with higher leverage, a higher ratio of securities bought under repurchase agreements to ass investment banks (BHCs with smaller ratios of risk-weighted assets to assets, smaller allocations to loans, and higher trading revenues), are less liquid. Thes industries, with different issuance sizes, and with different prior levels of liquidity.

The relationship between bond liquidity and institution-level constraints does, however, change significantly over time. **Adrian, Boyarchenko & Shachar (** return on assets, lower risk-weighted assets, lower reliance on repo funding, and lower vulnerability were more liquid. During the rule implementation perio lower leverage, higher risk-weighted assets, more reliance on repo funding, and lower return on assets were more liquid. That is, the relationship between b same relationship in the postcrisis period. These findings are consistent with more stringent leverage regulation and greater regulation of dealer banks redu

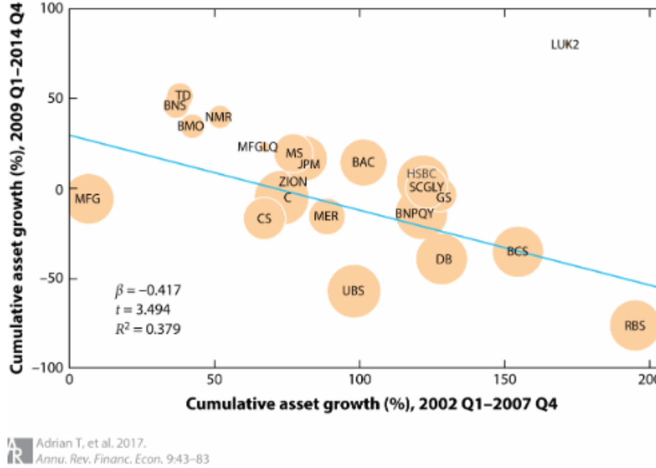
2.2. Consequences of the Housing Market Boom and Bust

Dealers' balance sheet management is reflective of their risk appetite. **Adrian & Shin (2010, 2014**) thus document that dealers' risk taking is closely tied to t tends to be compressed, dealers have loose VaR constraints, allowing them to expand their balance sheets by increasing leverage. When an adverse shock h amplification mechanism: Declining asset prices are associated with increased measured risk, forcing dealers to sell, thus inducing further price declines. Th

To investigate the effect of risk appetite on dealers' balance sheet contraction, we examine whether the cross section of dealers' risk-taking behavior during show that dealers that expanded their balance sheets more in the period before the financial crisis (2002–2007) tended to contract their balance sheets mor dealers' balance sheets documented by **Adrian & Shin (2010, 2014**).

Figure 3

Dealers' balance sheet expansions and contractions. This figure compares asset growth precrisis to asset growth postcrisis for the primary dealers for which data are available. Dots are labeled with each 2007. The asset-weighted least squares regression line is in blue. Data are from Compustat.



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Adrian et al. (2015g) further investigate the cross section of risk taking using the realized volatility of equity returns over the precrisis period as a measure o related academic study shows that the propensity to take risk across firms persists over time; see **Cheng, Hong & Scheinkman 2015**.) Furthermore, greater assets postcrisis. These findings are consistent with the interpretation that dealers' propensity to take risk amplified the growth of dealers' balance sheets g sheets after the crisis.

This evidence is thus suggestive of balance sheet contraction being related to dealers' risk-taking behavior in the run-up to the crisis. In particular, many Eur late 1990s and early 2000s, fueling the increase in aggregate balance sheet size. Furthermore, many major dealers significantly expanded their securitization growth before the crisis, and both factors are (cross-sectionally) associated with losses during the crisis and balance sheet reduction after the crisis.

2.3. Electronification

Another key development in recent years is the electronification of fixed-income markets. Electronification refers to the shift toward trading through compu and executions), and the reliance on speed to identify and act upon trading opportunities [that is, high-frequency trading (HFT)]. The growth of electronic tr dealers to step back from making markets and reducing their need for large balance sheets. The Joint Staff Report on the US Treasury market on October 15 now dominated by principal trading firms (PTFs), which typically execute HFT strategies.

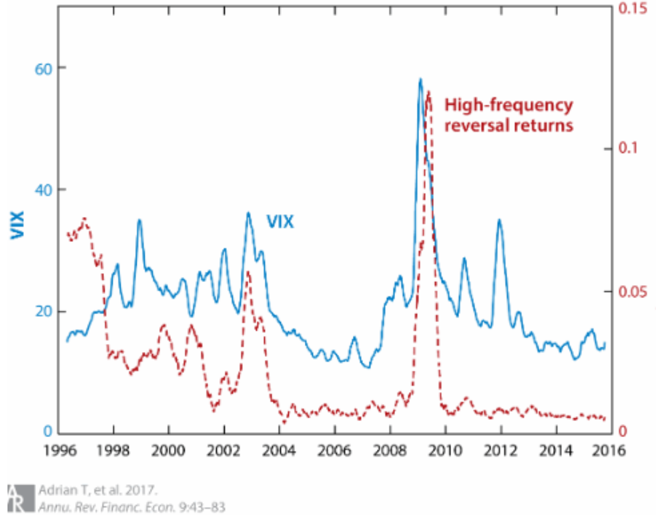
The Bank for International Settlements (**BIS 2016**) provides an overview of electronic trading in fixed-income markets and argues that electronic and autom show that automated trading is associated with a compression in bid-ask spreads, an increase in trading volume, and smaller trade sizes, on average (see th latency reduces bid-ask spreads, the total price impact of trades, and short-term volatility; **Hendershott, Jones & Menkveld (2011)** find that algorithmic tra trading strategy of a large high-frequency trader whose entry coincided with a 50% drop in the bid-ask spread.

However, automated trading may also be associated with an increase in liquidity risk, as suggested by the **BIS (2016)**. Some have thus linked the flash even the foreign exchange market on March 18, 2015, to the presence of automated trading [see **Securities and Exchange Commission (SEC) 2010**, **Joint Staff 2** average, but associated with costs in some states of the world.

To gauge the effects of electronification on market making, we estimate market-making returns in equity and corporate bond markets, following **Adrian et a** firms in the Dow Jones Industrial Average, using the methodology described by **Khandani & Lo (2007)** and **Nagel (2012)**. Returns are based on an investme past trends. The literature uses such reversal profits as proxies for expected returns to market making, as market makers tend to manage their trading book precipitously between the mid-1990s and mid-2000s and then stabilized at historically low levels, except for a temporary increase during the financial crisis. Exchange Volatility Index (VIX) through 2004, they were more stable than the VIX after that, except during the crisis, when both the VIX and the returns increa

Figure 4

High-frequency equity market returns. This figure plots the Chicago Board Options Exchange (CBOE) Volatility Index (VIX) alongside a proxy for high-frequency market-making returns in equities as calcu as described by **Khandani & Lo (2007)** and **Nagel (2012)**. Three-month moving averages are shown for both series. The equity data from which the market-making returns are calculated are from the Th



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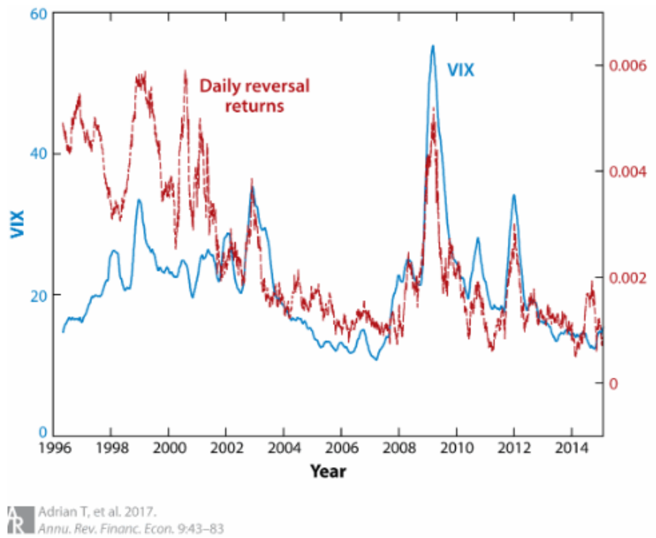
The decline in high-frequency market-making returns occurred against a backdrop of increasing competition. The expected returns to high-frequency tradi sector, as documented by **Budish, Cramton & Shim (2015)**. The sharp decline in high-frequency profits over the first 10 years of our sample suggests that t market-making profits did not increase after capital and liquidity regulations were tightened following the crisis.

Figure 5 shows that a somewhat different picture emerges for day-to-day market-making returns. Daily reversal trading returns for the firms tracked in the the mid-2000s and increased sharply during the crisis, with no discernible trend after the crisis. However, **Figure 5** also shows a high correlation between da relationship not observed for higher-frequency market making. The interpretation is that higher market volatility tightens dealers' funding constraints, cont directly on market volatility, such as VaR limits, can cause such funding constraints to bind and create a link between funding liquidity and market liquidity

Figure 5

Day-to-day equity market returns. The figure plots the Chicago Board Options Exchange (CBOE) Volatility Index (VIX) alongside a proxy for daily market-making returns in equities as calculated by a day-l **Nagel (2012)**. Three-month moving averages are shown for both series. The equity data from which the market-making returns are calculated are from the Thomson Reuters tick history; VIX data are fro



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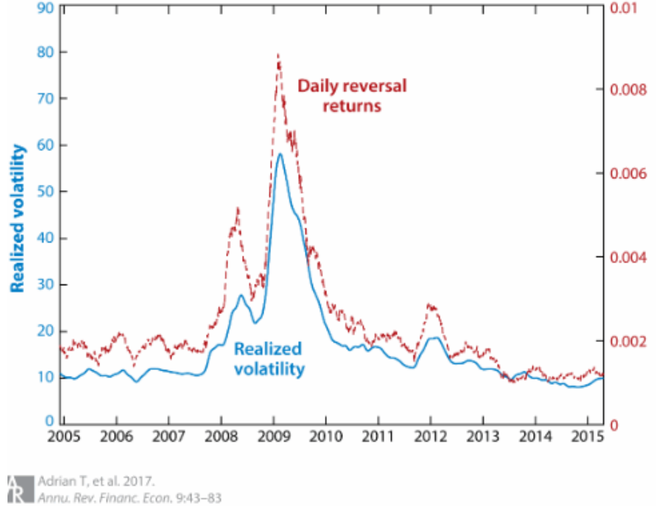
Whereas dealers play a modest role in equity markets, they remain the predominant market makers in the corporate bond market. Moreover, although elec involve HFT strategies. **Figure 6** shows that reversal returns for corporate bonds at the daily frequency exhibit no increase in market-making profits and the reveals a close relationship between returns to market making and corporate bond realized volatility, with returns to market making highest during high-vo

Figure 6

Day-to-day corporate bond market returns. This figure plots the cross-sectionally averaged monthly realized volatility of Markit's North American Investment Grade CDX Index constituents alongside a p **& Lo (2007)** and **Nagel (2012)**. The reversal strategy is applied to the same index constituents. Three-month moving averages are shown for both series. The daily returns are from FINRA's TRACE databa



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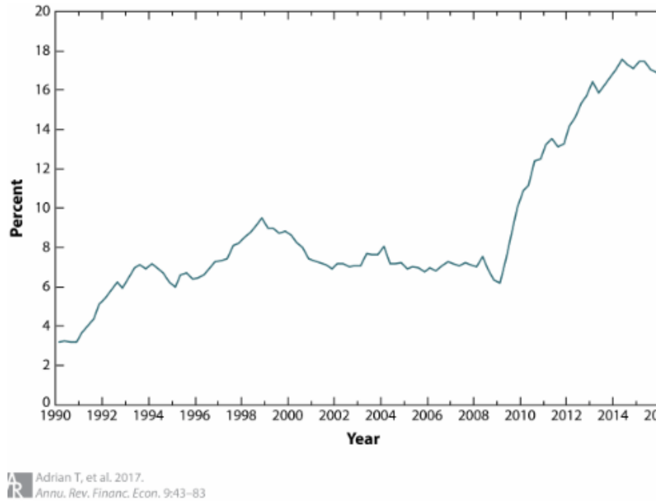
Overall, this evidence suggests that expected returns to market making remained compressed after the crisis, both in equity markets, where electronic HFT **Adrian et al. (2015a)** present complementary evidence by investigating the profitability of dealers. They find that postcrisis trading revenue for dealers liste volatility of trading revenue was much lower. It follows that the Sharpe ratio of trading revenue (aggregate revenue of dealers divided by the volatility of rev particular—Bank of America, Citigroup, Goldman Sachs, J.P. Morgan, and Morgan Stanley—was also much higher and less volatile after the crisis than before income figures suggest that dealers continue to play a key role in liquidity provision. This is particularly important for less liquid securities in which HFT firm of stress, when dealers have greater incentive to provide liquidity because of their customer relationships. The picture that emerges is of a change in the risk

2.4. Evolving Liquidity Demands of Large Asset Managers

As of mid-2016, mutual funds owned about 18% of corporate bonds, up from about 3% in 1990, as shown in **Figure 7** . The surge in ownership was strikingly financial crisis. Before the crisis, shadow credit intermediation was widespread, involving maturity transformation by money market funds that funded cred commercial paper conduits shrank sharply, and market-based credit intermediation shifted to bond funds. Although credit intermediation by bond funds st the maturity transformation of lengthy shadow credit intermediation chains that was common before the crisis.

Figure 7

Mutual fund ownership of corporate bonds. This figure plots corporate and foreign bonds outstanding (held in the United States) owned by mutual funds and exchange-traded funds as a fraction of the t Accounts of the United States published by the Board of Governors of the Federal Reserve System.



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Mutual funds' increased ownership of corporate bonds raises concerns about redemption risk. When mutual funds are subject to large redemptions, they ca relatively illiquid bonds. Such redemption risk is reinforced when redemptions are correlated across funds. Adverse pricing conditions in secondary markets that net bond fund flows (fund share purchases minus fund share redemptions) as a fraction of corporate bonds outstanding have not increased over time, s

Even if redemption risk has not increased, the price riskiness of corporate bonds could have increased owing to self-reinforcing dynamics: When adverse ne
reinforce the negative returns, thus generating additional redemptions (**Feroli et al. 2014**). Negative returns tend to be followed by net bond fund redempti
performance relationship.

The flow-performance relationship for equity mutual funds is generally found to be convex: Strong positive performance tends to generate an increasingly s
(2015) find a concave relationship for bond funds, so that flows react more strongly when returns are low. The concavity is more pronounced for illiquid bor
relationship for bond funds is both statistically and economically larger than that for equity funds. These results suggest that the illiquidity of corporate bon
adverse price changes. These incentives might also give rise to self-reinforcing redemption dynamics as investors might anticipate that it pays to redeem ea
more costly intermediation.

In contrast to mutual funds' increased ownership share of corporate bonds, dealers' ownership share of corporate bonds declined during and after the crisis
share raises the concern that dealers may no longer be able or willing to absorb selling pressure when redemptions force mutual funds to sell. **Adrian et al.**
weekly change in dealer corporate bond positions between January 2007 and August 2015. They find that dealer positioning tends to evolve in the same dir
selling pressure of bond funds. Given that dealers tend not to trade against bond fund flows, they surmise that dealers' falling corporate bond ownership sh

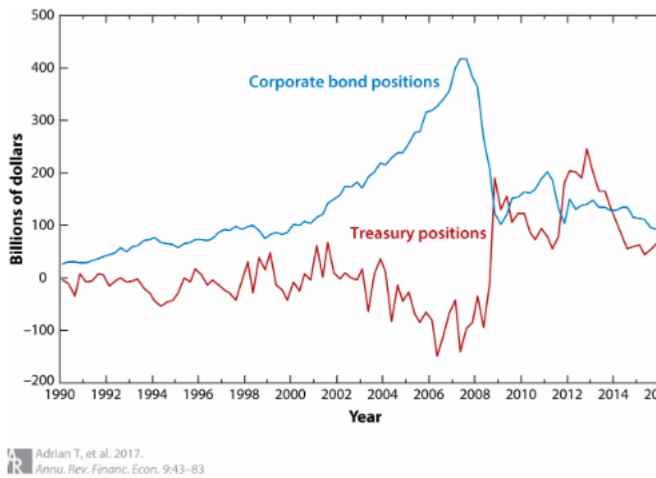
2.5. Changes in Expected Returns

Dealer positioning reflects the proprietary trading and risk-management motives of dealers as well as the positioning of dealer clients. To illustrate dealers'
positions in Treasury securities and corporate bonds from 1990 to 2016. The plot reveals three key features:

1. Dealers' net corporate positions grew quickly in the years preceding the crisis, plunged during the crisis, and stagnated after the crisis.
2. Dealers' net Treasury positions fluctuated between positive and negative between 1990 and 2016 and were negative for an extended period from 2004 to 2008.
3. In the roughly 15 years between 2001 and 2016, changes in net Treasury and corporate bond positions were negatively correlated and tended to offset, suggesting that d

Figure 8

Dealers' corporate bond and Treasury positions. This figure plots corporate bond (domestic and foreign) and Treasury security positions (held in the United States) of security broker/dealers. Data are fro



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The sharp decline in net corporate positions, in particular, raises the concern that dealers have reduced their capital commitment to market making, with p
bonds from their customers when they wanted to sell, and holding them on their balance sheet until offsetting trades were found later, thus bearing the risk
agency model, as suggested by **Barclays (2016)**, **Bessembinder et al. (2016)**, and **Choi & Huh (2016)**, in which dealers match offsetting orders so as to avo
net positions, it leaves open the question as to whether liquidity is adversely affected. There are tens of thousands of outstanding corporate bond issues wit
demand and supply.

Across all debt securities, dealer positioning is likely managed to maximize expected returns and hence varies over time. In **Figure 9** , we plot debt securitie
returns: the sum of the 10-year Treasury term premium and the credit risk premium. The 10-year Treasury term premium, computed by **Adrian, Crump & M**
portfolio with a 10-year duration. The credit risk premium is measured by Moody's Baa-Aaa spread. The figure shows a tight correlation (55%) between expe
changes in asset valuations typically accompanied by sharp adjustments in positions. The low level of debt securities as a share of total assets prior to the fi
Similarly, the sharp rise in debt securities during the crisis corresponded with a period when expected returns were unusually high. For further analysis, see

Figure 9

Dealers’ debt security positions and expected returns. This figure shows dealers’ debt securities as a percentage of their total financial assets together with a measure of expected fixed-income returns. D
commercial paper, and municipal bonds. Expected returns to fixed-income securities are computed as the 10-year Treasury term premium from **Adrian, Crump & Moench (2013)** plus Moody's Baa-Aaa c
States published by the Board of Governors of the Federal Reserve. Term premium data are from the Federal Reserve Bank of New York. Credit spread data are from the Board of Governors of the Federal

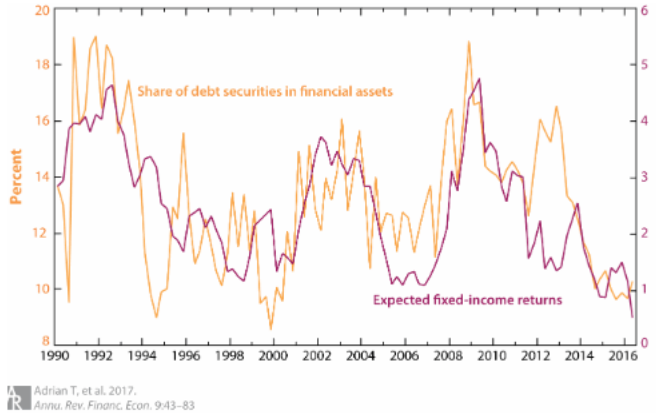

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Figure 9 does suggest one exceptional period in 2012 and early 2013, when dealer positions were increasing despite ever more compressed expected returr
might be overheating, and the Financial Stability Oversight Council (**FSOC 2013**) issued a similar warning in its annual report. That episode ended with the b
quickly shed fixed-income positions (**Adrian & Fleming 2013**). In 2014, the tight link between dealer positions and expected returns returned, with both de

3. EMPIRICAL EVIDENCE ON MARKET LIQUIDITY

We proceed to assess the extent to which the changes that have roiled dealers’ balance sheets have affected liquidity in the US Treasury and corporate bonc
the US government and corporate bond markets are the largest of their kind, with debt outstanding of $13.4 trillion and $8.4 trillion, respectively, as of June
US government and corporations; as investment vehicles; and (in the case of the Treasury market) as a hedging vehicle, risk-free benchmark for pricing othe

We define market liquidity as the cost of quickly converting an asset into cash (or vice versa). Liquidity has multiple dimensions, so we examine several mea
using data from 2005 to 2016. We then consider three case studies of market stress in the postcrisis era to shed light on the resilience of market liquidity.

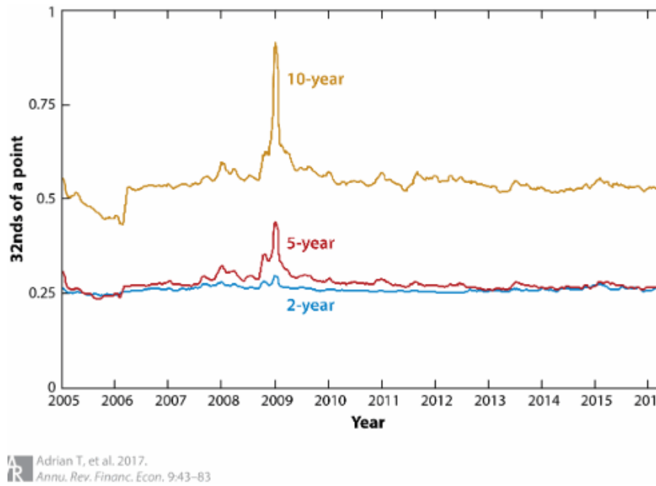
3.1. Evidence from the US Treasury Market

We consider four common liquidity measures for the Treasury market, all calculated using high-frequency data from the interdealer market. [2] Our measures
three most actively traded Treasury securities. Our sample runs from the beginning of 2005 through June 2016, so it covers the 2007–2009 financial crisis, th

One of the most direct liquidity measures is the inside bid-ask spread: the difference between the highest bid price and the lowest ask price for a security. Th
typically calculated as one-half of the bid-ask spread. As shown in **Figure 10** , average bid-ask spreads widened markedly during the crisis, but were narrow

Figure 10

Bid-ask spreads of US Treasury securities. The figure plots 21-day moving averages of average daily bid-ask spreads for the on-the-run notes in the interdealer market. Spreads are measured in 32nds of



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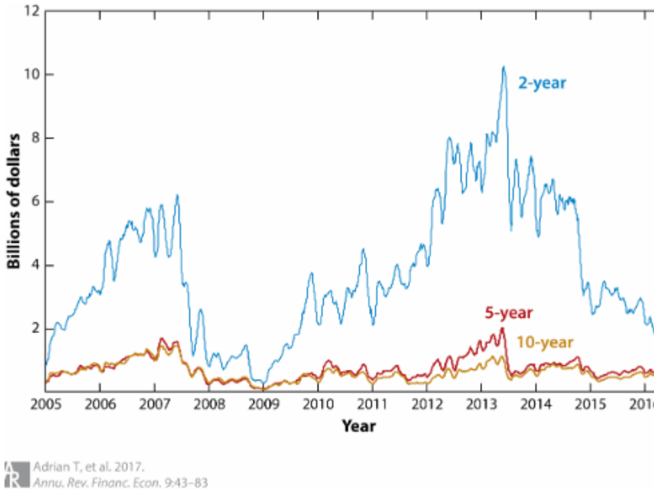
Although the bid-ask spread directly measures transaction costs and hence liquidity, it does not account for the depth of the market and hence how costs m
measure is that the minimum tick size (one-half of one 32nd of a point for the 10-year note and one-quarter of one 32nd for the 2- and 5-year notes) is frequ

The quantity of securities that can be traded at various bid and offer prices helps account for the depth of the market and complements the bid-ask spread a
explicitly bid for or offered for sale at the best five bid and offer prices in the BrokerTec limit order book. **Figure 11** shows that average depth rebounded hea
October 2014 flash rally, thus painting a less sanguine picture of Treasury market liquidity.

Figure 11

Depth of US Treasury securities. This figure plots 21-day moving averages of average daily depth for the on-the-run notes in the interdealer market. Depth is summed across the top five levels of both sid



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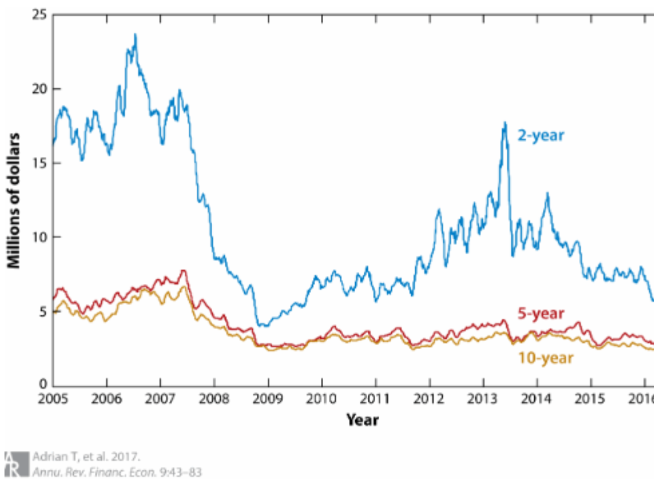
A key limitation of the depth measure is that it does not consider the spread between quoted prices, including the inside bid-ask spread, and as such does n
is that market participants often do not reveal the full quantities they are willing to transact at a given price, so that measured depth may underestimate tru
with which orders can be withdrawn from the market, actual depth may instead be lower than what is posted in the limit order book.

An alternative measure of market depth is trade size. Trade size is an ex-post measure of the quantity of securities traded at the bid or offer price, reflecting
the crisis, increased markedly after, and then declined again during the taper tantrum and around the flash rally of October 2014, as shown in **Figure 12** .

Figure 12

Trade sizes of US Treasury securities. This figure shows 21-day moving averages of average daily trade sizes for on-the-run notes in the interdealer market. Data are from BrokerTec.



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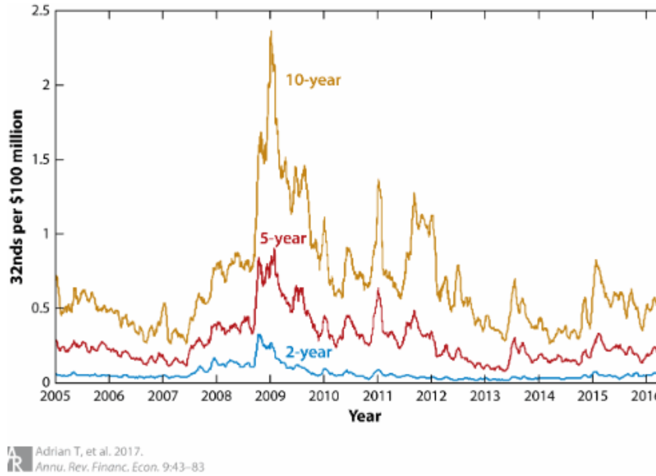
One difficulty in interpreting trade size is that it underestimates market depth because the quantity traded is often less than the quantity that could have be
particular, may reflect the increasing prevalence of HFT in the interdealer market, and not necessarily reduced liquidity. In addition, trade size does not con
measure transaction costs.

A popular measure of liquidity, suggested by **Kyle (1985)**, considers the rise (or fall) in price that typically occurs with a buyer-initiated (or seller-initiated) tr
change to trade size and is often estimated by regressing price changes on net signed trading volume (positive for buyer-initiated volume and negative for s
large trades or a series of trades and, together with the bid-ask spread and depth measures, provides a fairly complete picture of market liquidity.

Measures of price impact also suggest some deterioration of liquidity over the 2013–2015 period. **Figure 13** plots the estimated price impact per $100 millio using bid-ask midpoints) on net trading volume over the same 5-minute interval. Price impact rose sharply during the crisis, declined markedly after, and th measure remained somewhat elevated after October 15, 2014, but was not especially high in 2015 and 2016 by historical standards.

Figure 13

Price impact of US Treasury securities. This figure plots 4-week moving averages of slope coefficients from weekly regressions of 5-minute price changes (calculated using bid-ask midpoints) on 5-minut



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Overall, we find mixed evidence on Treasury market liquidity in the postcrisis era. The appreciable declines in quoted depth in mid-2013 and late 2014 may suggest a more modest deterioration, and bid-ask spreads, which directly measure the cost of trading, remained narrow by recent histo-rical standards as o reflect the growth of automated trading and associated changes in order submission strategies, and are not necessarily indicative of worse liquidity.

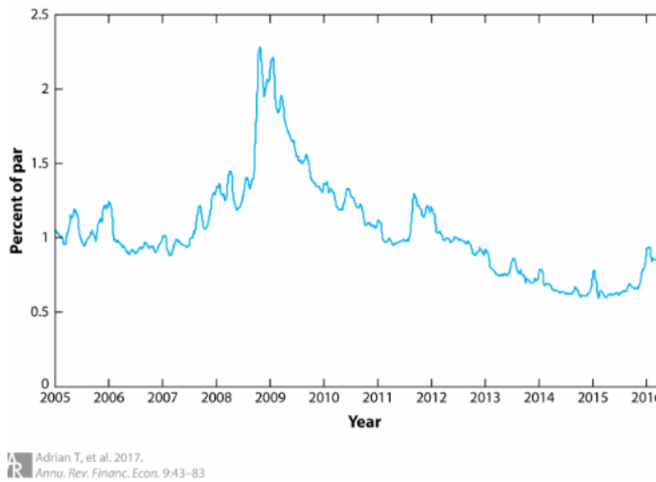
3.2. Evidence from the US Corporate Bond Market

In this section, drawing on the work of **Adrian et al. (2015c**, **2016a**), we analyze some of the same measures for the US corporate bond market as for the US associated data. Secondary market trading of corporate bonds is conducted over the counter, with most trading intermediated by dealers. There is no centr therefore infer liquidity from the record of transactions as reported in FINRA's TRACE database, introduced in 2002. [4]

We calculate realized bid-ask spreads for each bond and day as the difference between the average price at which customers buy from dealers and the avera bid-ask spreads across bonds for each day. As shown in **Figure 14** , average bid-ask spreads widened sharply during the crisis, but then narrowed to levels l

Figure 14

Corporate bond bid-ask spreads. This figure shows the 21-day moving average of realized bid-ask spreads for corporate bonds. The spreads are computed daily for each bond as the difference between t and then averaged across bonds using equal weighting. Data are from FINRA's TRACE database.



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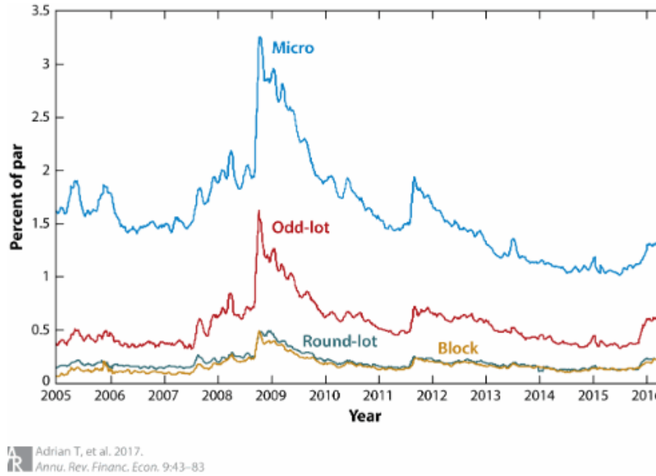
The evolution of realized bid-ask spreads is broadly robust to the subsample and to the estimation approach. We find generally similar patterns when we co **(2007)** show (and which our findings confirm) is negatively correlated with transaction costs. Similar patterns are also observed when we condition on cred trading volume across bonds instead of weighting equally across bonds results in appreciably lower spreads, but the same general pattern. That said, a nota for retail (<$100,000) trades, but are wider for institutional (≥$100,000) trades, a difference also noted by **Anderson & Stulz (2017)**.

Figure 15

Corporate bond bid-ask spreads by trade size. This figure shows 21-day moving averages of realized bid-ask spreads for four different trade size groupings: micro (<$100,000), odd-lot ($100,000–1 millior
category as the difference between the average (volume-weighted) dealer-to-client buy price and the average (volume-weighted) dealer-to-client sell price and then averaged across bonds using equal v



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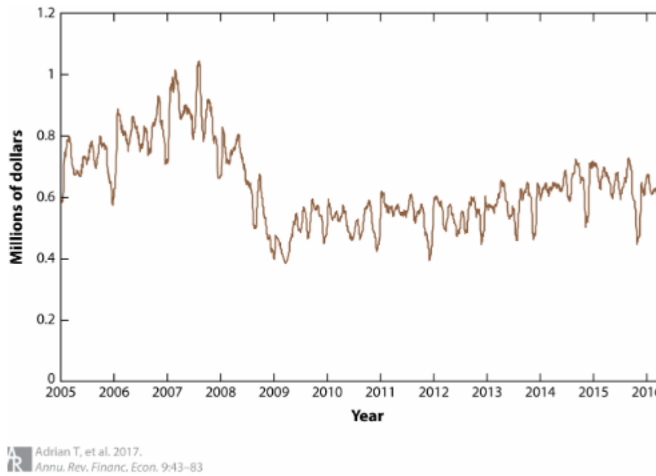
Although we cannot calculate order book depth for the corporate bond market, we can look at trade size. Average trade size declined sharply during the cris
this trend as evidence that investors find it more difficult to execute large trades and so are splitting orders into smaller trades to lessen their price impact.

Figure 16

Corporate bond trade size. This figure shows the 21-day moving average of average trade size. Average trade size is calculated daily as total trading volume divided by the number of trades. Data are fron



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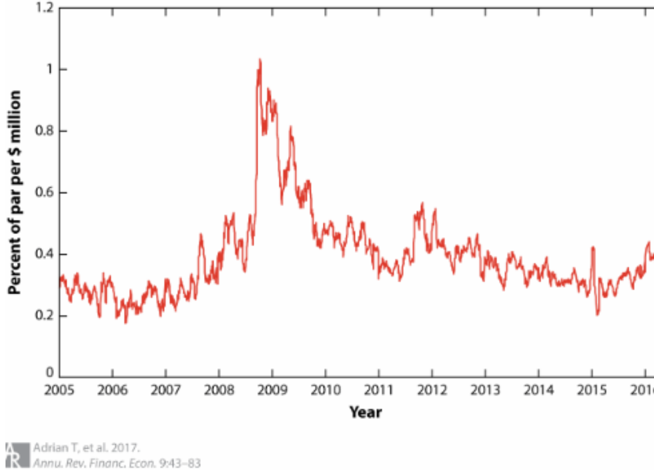
In fact, there is evidence of higher price impact after the crisis versus before the crisis. We calculate price impact for each institutional trade as the price char
customer buys and negative when the customer sells). We average these estimates for each bond and day and then average across bonds for each day. As sl
declined, but remained above precrisis levels. **Anderson & Stulz (2017)** also find somewhat higher price impact for large trades after the crisis than before.

Figure 17

Corporate bond price impact. This figure shows the 21-day moving average of price impact for institutional (≥$100,000) trades. Price impact is calculated for each such trade as the price change from th
customer sells). These are averaged daily for each bond using equal weighting and then averaged across bonds using equal weighting. Data are from FINRA's TRACE database.



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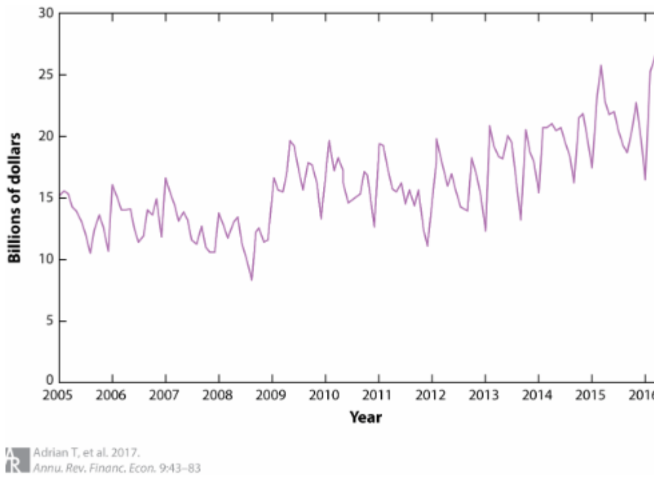
Additional measures suggest ample corporate bond market liquidity. Trading volume, for example, declined during the crisis but rebounded to record highs rebounded sharply after, reaching record highs in each year from 2012 through 2016 and driving debt outstanding to ever higher levels. Some analysts note remains below precrisis levels, but it is not obvious that declining turnover amid growing volume indicates worse liquidity.

Figure 18

Corporate bond trading volume. This figure shows average daily trading volume by month across all publicly traded nonconvertible corporate debt, medium-term notes, and Yankee bonds (excluding iss Markets Association and are based on data from FINRA's TRACE database.



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As for the Treasury market, the overall evidence on liquidity in the corporate bond market in the postcrisis era is mixed. Bid-ask spreads for retail trades dec volume and issuance rose to record highs. However, trade size declined during the crisis and did not quickly rebound after, consistent with the hypothesis th and price impact for institutional trades remained higher after the crisis than before, suggesting somewhat worse liquidity for these larger trades.

3.3. Case Studies of Market Liquidity Events

We present three case studies of market behavior during times of stress in the postcrisis era to better understand the resilience of market liquidity. The first the end of the Federal Reserve's large-scale asset purchases. The second is the flash rally in the US Treasury market on October 15, 2014, when Treasury yiel liquidation of Third Avenue's high-yield Focused Credit Fund (FCF) in December 2015.

3.3.1. Dealers' balance sheet capacity and market liquidity during the taper tantrum.

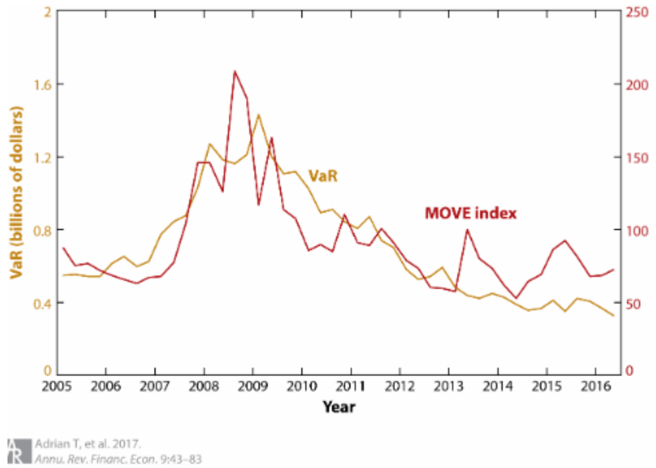
Long-term interest rates increased substantially in 2013 after hitting record lows in 2012. The sharpest increase occurred between May 2 and July 5, 2013, wi liquidity deteriorated during this episode, as shown in **Figures 11** and **13** by the sharp drop in market depth and increase in price impact between May and J the Joint Economic Committee on May 22 and the Federal Open Market Committee meeting on June 18 and 19. Some market participants suggested that co the magnitude and speed of the rise in interest rates and volatility (see, e.g., **Cameron & Becker 2013**). Dealers intermediate between buyers and sellers, pu capacity a dealer has to absorb supply and demand imbalances, the higher volatility and the lower market liquidity are likely to be. In this section, we review balance sheet capacity amplified the sell-off.

To gauge dealer willingness to add interest rate risk exposure and buffer the selling pressures from their customers, **Adrian et al. (2013)** examine dealers' p
reported to the Federal Reserve by primary dealers. During the sell-off, dealers markedly reduced their net positions (the difference between long and short
they had decided to limit their outright exposures rather than absorb inventory from customers looking to sell. Moreover, the biggest decline in dealers' lon
their market-making activities during the sell-off. Outside of 2013, instances since 1990 in which there were larger changes in both long and short positions
the bond market sell-off of 1994, and around the financial market turmoil of 1998.

Another indicator of risk taking is VaR, which measures the worst expected loss over a given time horizon at a given confidence level. **Figure 19** shows that t
The figure also shows that VaR tends to move in tandem with market volatility, as proxied by the Merrill Lynch Option Volatility Estimate (MOVE) index, so th

Figure 19

Dealer value at risk (VaR) and interest rate volatility. This figure plots the sum of firm-wide VaR across eight large US firms (Bank of America, Bear Stearns, Citibank, Goldman Sachs, J.P. Morgan, Lehman
of implied interest rate volatility. Data are from Bloomberg.



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Interestingly, dealer VaR did not increase during the 2013 sell-off, although volatility rose sharply, suggesting that dealers might have actively managed thei
the cross-sectional behavior of dealers highlights the observation that firms that reduced their net fixed-income positions more during the sell-off tended t
dealers that reduced their positions more experienced larger increases in their tier 1 capital and tier 1 leverage ratios in the second quarter of 2013. That is,
reduction in risk taking.

Table 1

Dealers' net positions and balance sheet constraints during the 2013 sell-off

Toggle display: Table 1 **Open Table 1 fullscreen (/content/tab**

Measure of dealer constraint (Period over which constraint changes)	Correlati
Change in interest rate VaR (May 1 to July 10, 2013)	
Change in tier 1 capital ratio (March 31 to June 30, 2013)	
Change in tier 1 leverage ratio (March 31 to June 30, 2013)	

The table presents pairwise correlations between dealers' changes in net positions in US Treasury securities, agency debt, agency mortgage-backed securities, and corporate securities during the May–July 2013 sell-off and c
risk (VaR) data, company reports for major US chartered bank-holding company affiliated dealers, and the Federal Reserve's FR2004 statistical release.

The finding that dealers reduced their fixed-income positions during the sell-off and that the reduction was associated with reduced risk taking as measure
first is that dealers were unable to provide market liquidity because of capital constraints. The second is that dealers decided to manage their balance shee
is, dealers may have been able but unwilling to provide market liquidity.

If the constraints explanation were correct, then dealers facing tighter balance sheet constraints before the sell-off would have been expected to reduce the
2 is not consistent with that hypothesis. In particular, US dealers with a higher VaR gap (which measures the difference between a dealer's VaR and its VaR li
dealer's measured ratio and proposed ratio requirement), and higher tier 1 capital and tier 1 leverage ratios before the sell-off tended to reduce their net po

sell-off actually sold off more. This relationship suggests that dealer behavior during the sell-off was not driven by regulatory constraints.

Table 2

Dealer changes in net positions and balance sheet constraints prior to the 2013 sell-off

Toggle display: Table 2 **Open Table 2 fullscreen (/content/tab**

Measure of dealer constraint (Date prior to sell-off)	Correlat
VaR gap (May 1, 2013)	
Basel III tier 1 common ratio buffer (March 31, 2013)	
Tier 1 capital ratio (March 31, 2013)	
Tier 1 leverage ratio (March 31, 2013)	

The table presents pairwise correlations between dealers' changes in net positions in US Treasury securities, agency debt, agency mortgage-backed securities, and corporate securities during the May–July 2013 sell-off and c company reports for major US chartered bank-holding company affiliated dealers, and the Federal Reserve's FR2004 statistical release.

Instead, the evidence supports the second hypothesis: Dealers were less willing to employ their balance sheets as market participants reassessed fixed-inco the stance of monetary policy. Prior to the sell-off, the term premium—the risk premium investors demand for bearing duration risk—had been very low, or c Some investors (including dealers) may have viewed valuations as stretched and may have been waiting for a trigger for the market to reverse. Events in Ma exposures and shrinking their inventories.

3.3.2. The Treasury flash event of October 15, 2014.

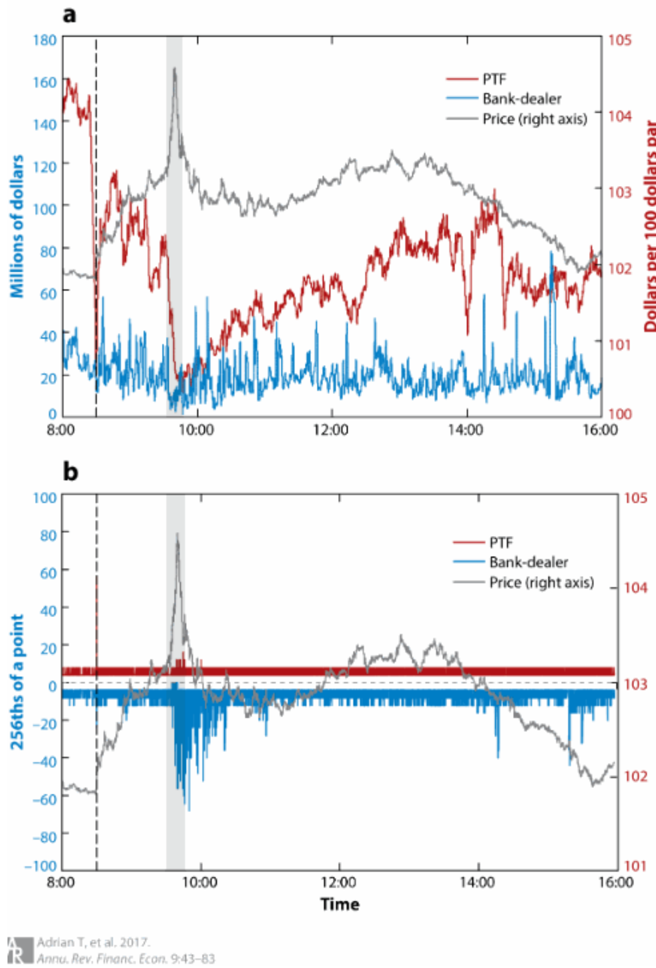
On October 15, 2014, the US Treasury securities market experienced an unusually high level of volatility and a rapid round-trip in prices. The benchmark 10- opening level. Moreover, between 9:33 and 9:45 AM Eastern time, without a clear cause, the 10-year yield declined 16 basis points and then rebounded. Such unprecedented in the recent history of the Treasury market.

As explained in the report of the **Joint Staff (2015)**, PTFs and bank-dealers, in that order, accounted for the largest shares of trading volume in both the cash window, the relative share of PTF trading activity increased as prices and volume rose sharply. Although the share of trading shifted toward PTFs, both PTFs overall volume. As the prices quickly retraced their previous increases, the share of PTF trading activity declined somewhat from its elevated levels and the s

PTFs and bank-dealers took actions to reduce their risk exposure to volatility during the event window. PTFs continued to provide the majority of order boo contrast, bank-dealers widened their bid-ask spreads such that they provided limit orders only at some distance from the top of the book.

Figure 20

Liquidity during the October 15, 2014, Treasury flash event. (*a*) Limit order book depth at the top three levels in the on-the-run 10-year note as provided by principal trading firms (PTFs) and bank-dealers reproduced from the report of the **Joint Staff (2015)**; data are from BrokerTec.



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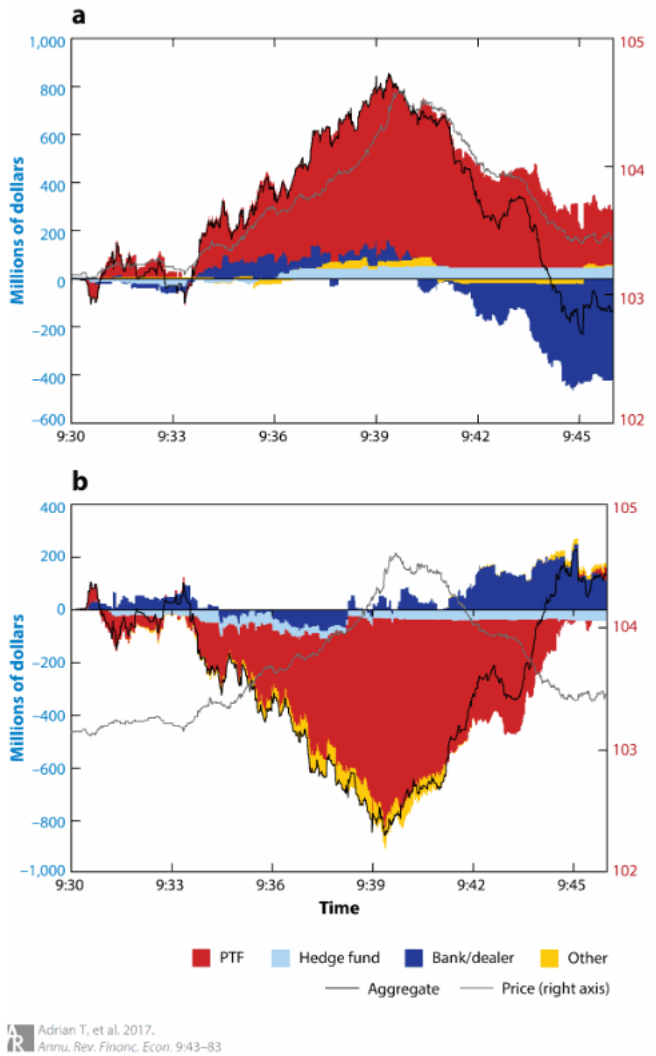
Despite the surge in trading volume during the event window, available data do not show a large change in net position of any specific participant type at th initiated trades is observed, primarily driven by PTFs, with more buyer-initiated trades as prices rose and more seller-initiated trades as prices fell (see **Figur** PTFs were large net passive sellers during the first part of the event window and large net passive buyers during the second part of the window (see **Figure 2** flows, so that, as a group, PTFs' net position remained largely unchanged throughout the event window, suggesting that they were deploying multiple types significant market-making activity during the event window.

Figure 21

Net trading volume during the October 15, 2014, Treasury flash event. (*a*) Cumulative net aggressive trading volume in the on-the-run 10-year Treasury note by participant type during the 9:30–9:45 AM ev report of the **Joint Staff (2015)**; data are from BrokerTec. Abbreviation: PTF, principal trading firm.



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Although the report of the **Joint Staff (2015)** revealed no single cause for the price behavior during the event window, it did highlight a number of importar increase in trading volume, sizeable changes in market participation, a decline in market depth, and shifts in net order flow, which together provide insight i structure in recent years have been significant. These changes are likely important context for understanding the unusual volatility that day and for assessir

3.3.3. Third Avenue's liquidation and corporate bond liquidity in 2015.

Third Avenue's high-yield FCF announced liquidation on December 9, 2015, drawing widespread attention in asset markets. Events of this kind have the pote risk exposures, and fulfill the need to trade. Moreover, portfolio effects and general fears of contagion may increase the demand for liquidity in assets only r FCF's announced liquidation affected liquidity and returns in broader corporate bond markets.

In the weeks and months preceding its liquidation, FCF experienced an ever-increasing outflow of investor assets, similar to a run. The investor redemptions redemptions. This created a direct and mechanical need for immediacy in the segment of the corporate bond market in which FCF specialized. There are at liquidity strains in such a scenario.

First, a publicized risk event like FCF's announced liquidation may raise expectations of redemptions at other funds. To meet those expected redemptions, f moment's notice and with low cost. Similarly, these managers may have a preference for safe bonds that can prevent their funds' values from declining furt can become temporarily one-sided, leading to shortages of safe and liquid bonds and, hence, to strains on market liquidity more broadly.

Second, FCF's liquidation occurred against a backdrop of heightened uncertainty in corporate bond markets. Rising credit spreads, increased costs for defau change in the Federal Reserve's monetary policy stance were all common themes affecting markets at the time. Against that backdrop, a highly observable s need to hedge and reduce exposures, further increasing the demand for immediacy.

To assess how FCF's closure affected broader market liquidity, **Adrian et al. (2016b**) examine the corporate bond market liquidity measures discussed abov December 11, 2015, to group bonds by their price sensitivity to news about Third Avenue. [6] Bonds with the worst returns on December 11 tended to (*a*) have yield to a greater extent. These findings support the view that FCF's announced closure triggered a wider sell-off of risky assets.

Bonds with the worst returns on December 11 also exhibited somewhat worse liquidity that day, with wider bid-ask spreads and higher price impact. Howe was consistently less liquid than bonds in the other performance quintiles. Thus, the event appeared to have the greatest (negative) effects on price and bid were modest in magnitude and did not spill over into the broader universe of corporate bonds.

4. DIRECTIONS FOR FURTHER RESEARCH

Although we do not uncover strong evidence of a widespread worsening of market liquidity, our findings are not unqualified because of data and methodol overcome these shortcomings. Our discussion focuses on five areas: (*a*) additional data, (*b*) methodological improvements, (*c*) endogeneity, (*d*) liquidity risk

4.1. Additional Data

A major challenge in accurately measuring market liquidity is inadequate data. For example, in the corporate bond market, trade prices and limited trade si corporate bond limit order book is mostly latent. Thus, information on the quantity that could have been traded at the transaction price or other prices is n in a trade are not reported. In recent years, electronic trading venues for corporate bonds have started to collect such data, but these venues represent only of broader liquidity conditions.

Fragmented markets present a further challenge to obtaining comprehensive liquidity data. A given asset may trade in scattered liquidity pools or trading v clienteles. Data on liquidity conditions in one liquidity pool may not be representative of liquidity conditions elsewhere. In the interdealer Treasury market, with extraordinary liquidity and data. However, significant trading in the full range of Treasuries occurs in the dealer-to-customer (DtC) market, which is kno **Schaumburg 2016**). Thus, although high-quality liquidity measures can be calculated in the IDB market for on-the-run Treasury securities, these may not b securities.

Along similar lines, derivatives markets offer alternative methods for replicating cash flows and creating synthetic risk exposures. Thus, liquidity challenges or swaps. The effect of including these alternative channels for transferring risk directly affects certain liquidity measures. For instance, the price impact me trading volume, so the omission of, say, Treasury futures trading volume may lead to an underestimate of liquidity. A comprehensive study of liquidity cond substitutes.

4.2. Methodological Improvements

Liquidity measures that work well in some markets do not necessarily extend to other markets. As an example, consider the problem of computing depth in quantity an investor can trade at the best bid or offer price. Although an investor may assess this quantity by inquiring with individual dealers, the investor's problem is compounded by the fact that depth available to investor A for a specific security may not be the same depth available to investor B at roughly th trading and may reflect investors' differential information content of order flow or varying treatment from dealers, reflecting client relationships (**Di Maggio**

Facing limited information, researchers construct proxies from observable data to infer properties of unobservable data. For example, **Dick-Nielsen, Feldhü** information akin to bid-ask spreads. Similarly, **Bessembinder et al. (2016)** use indicator variable regressions to estimate unobserved liquidity variables. Ho selection problem: If only liquid securities trade, then only liquid securities make it into the liquidity calculations and estimates are biased toward higher li

It follows that broad aggregates of standard market liquidity measures may mask pockets of illiquidity. **Adrian et al. (2016c**) attempt to address this concer characteristics. They find that retail bid-ask spreads were narrower after the crisis than before, on average, but that institutional bid-ask spreads were wide grade bonds, but were essentially unchanged for high-yield bonds, on average. **Sommer & Pasquali (2016)** provide guidance on which bond characteristics coupon rate, price volatility, and central bank eligibility.

Market participants have informally referred to the concentration of liquidity in certain subsets of the bond market as a liquidity bifurcation, with trading co issued bonds. More closely studying the causes and consequences of liquidity bifurcation could be an interesting area of research. For example, liquidity bif (**Brunnermeier & Pedersen 2009**) who seek to avoid capital-intensive positions in high-margin securities. Because margins for high-yield bonds tend to be investment-grade bonds is consistent with this theory, but this is in need of further investigation.

Another important issue concerns strategic quoting. There are indications that certain cross-venue HFT firms display depth in related markets without the i **(2015)** present evidence that trades against resting quotes in the Treasury futures market are followed by almost instantaneous reductions in depth in the T venues, in the sense that the displayed total depth across trading venues is not the actual quantity available for trade. This type of behavior reinforces the n changes in market structure and investor composition.

4.3. Endogeneity

The endogenous response of market participants to changing liquidity conditions can also create biases in traditional liquidity measures. Both academic ar shift from a principal model of market making to an agency model (e.g., **Barclays 2016**, **Bessembinder et al. 2016**, and **Choi & Huh 2016**). In a principal mo securities in their inventory and are compensated for the opportunity cost of capital and the inventory risks incurred through the bid-ask spread. In an agen and the bid-ask spread is presumably narrower. Thus, in a regime where capital-constrained dealers endogenously avoid carrying large inventories, bid-ask setting, the investor now bears inventory risk during the time it takes the market maker to locate the other side of the trade, suggesting that liquidity has no least interpreted with caution.

A further challenge to measuring future, or expected, liquidity comes from the observation that liquidity can endogenously appear during risk events. When enter the market to fulfill the need to trade. During such episodes, liquidity can improve as buyers and sellers arrive in the market at the same time, essenti phenomenon occurs regularly as a result of Treasury auctions, which lead to higher volatility and also trigger trading. These observations have several impl liquidity, although the effect may be nonlinear: Moderate increases in volatility may come with higher liquidity, whereas large increases in volatility may res necessarily exacerbate volatility is perhaps oversimplified, as it assumes that liquidity provision, if low, remains exogenously low. Third, current measures o responsive to the economic environment.

Conversely, in the absence of a shock, investors may wait to transact, suggesting that investors' decision to pay for immediacy services or to wait to trade at show theoretically that realized trades are the equilibrium outcome determined by the supply and demand for immediacy. Thus, in environments in which i immediacy services (and hence the returns to providing liquidity) can decline. An implication is that infrequent trading may simply reflect low expected vola

4.4. Liquidity Risk

The October 15, 2014, flash rally in the US Treasury market and the May 2010 equity market flash crash highlight that market liquidity and pricing are subjec **Commission (CFTC) & SEC 2010**, **Joint Staff 2015**]. **Adrian et al. (2015e,b**) model illiquidity dynamics as consisting of a continuous Gaussian component changes in illiquidity tend to occur at times of high volatility. The authors also find somewhat elevated liquidity risk, as measured by the illiquidity jump inte reconciled by the fact that HFT, which is a common feature in markets that experience flash events, has not taken hold in the corporate bond market as it ha is based on daily measures of liquidity and may be improved by using higher-frequency intraday measures.

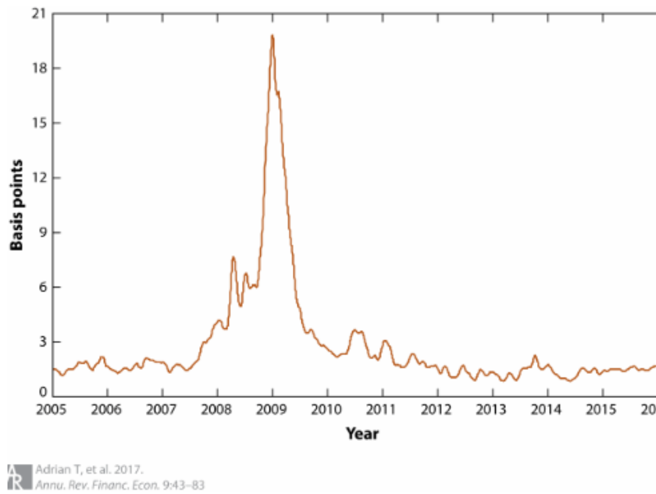
4.5. Funding Liquidity

Theoretical asset pricing models, such as the one proposed by **Brunnermeier & Pedersen (2009)**, suggest a feedback loop or "spiral" connecting market lic improves market liquidity and lowers volatility. Lower volatility then allows lenders to lower margin requirements or haircuts applied to collateral in repo tr liquidity dissuades capital-constrained investors from taking positions, adversely affecting market liquidity. A potential consequence is an increased concer perspective, the tight link between funding liquidity and market liquidity suggests further study of their joint evolution, as opposed to study of each in isola

One measure in the Treasury market closely linked to both market liquidity and funding liquidity gauges the noisiness of Treasury yields around a smoothed this measure as the average absolute yield curve fitting error for coupon-bearing securities from the Nelson–Siegel–Svensson model of **Gürkaynak, Sack &** could reflect constraints on market-making capacity and/or poor liquidity. As shown in **Figure 22** , such pricing differences spiked during the crisis, but were

Figure 22

Spline errors of US Treasury securities. This figure shows the 21-day moving average of absolute yield curve fitting errors for 2- to 10-year coupon securities from the Nelson–Siegel–Svensson model of G



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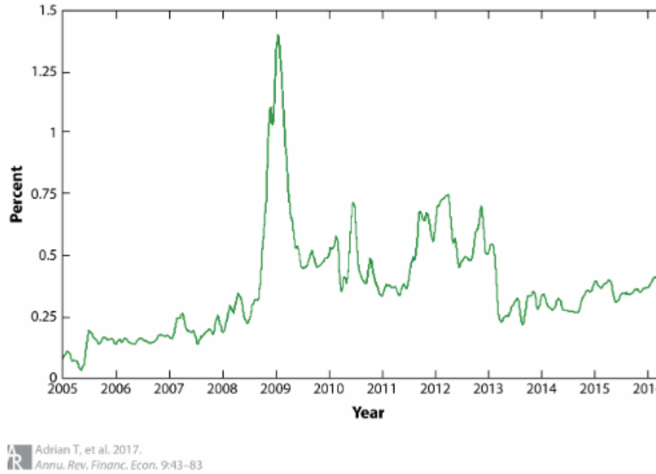
A second measure closely tied to both market liquidity and funding liquidity is the RefCorp spread: the yield spread between bonds of the Resolution Fundi
because RefCorp bonds and Treasury securities are equally creditworthy, but RefCorp bonds are less liquid, the RefCorp spread solely reflects the value of t
crisis and was close to postcrisis lows in the 2013–2016 period, albeit somewhat above precrisis levels.

Figure 23

The RefCorp–US Treasury spread. This figure shows the 21-day moving average of the RefCorp spread, which is the difference in yield between a 10-year Resolution Funding Corporation zero-coupon bo



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Alternative funding liquidity measures also warrant attention. **Figure 24** plots the spread between the 10-year interest rate swap and the 10-year Treasury y
Interbank Offered Rate), so their pricing depends on the credit risk of LIBOR-panel banks. Treasuries, in contrast, price in the credit risk of the US governme
positive. However, such spreads were negative at times in 2010 and also turned negative in late 2015 (remaining so through mid-2016). Such negative swap
sometimes attributed to regulatory balance sheet constraints on banks, hedging demands, and foreign central bank activities.

Figure 24

Funding cost measures. This figure plots the 10-year interest rate swap spread and the credit default swap (CDS)-bond basis for investment-grade bonds. The 10-year swap spread is computed as the dif
Governors of the Federal Reserve System. The CDS-bond basis is from J.P. Morgan and is computed for investment-grade corporate bonds as the average difference between each bond's market CDS spr
been obtained from sources believed to be reliable, but J.P. Morgan does not warrant its completeness or accuracy. The CDS-bond basis index is used with permission and may not be copied, used, or di

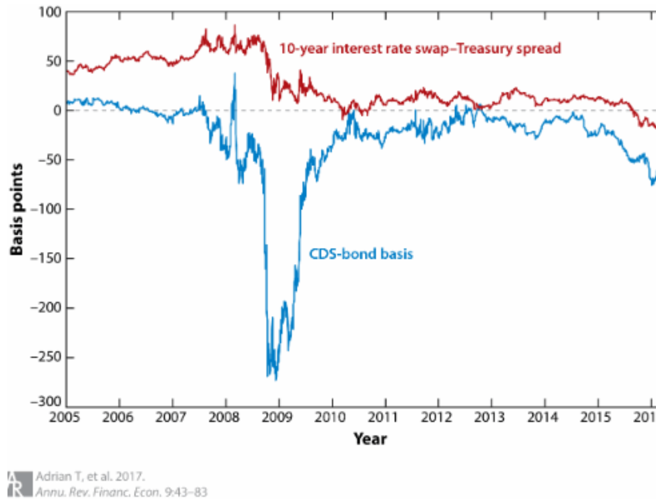

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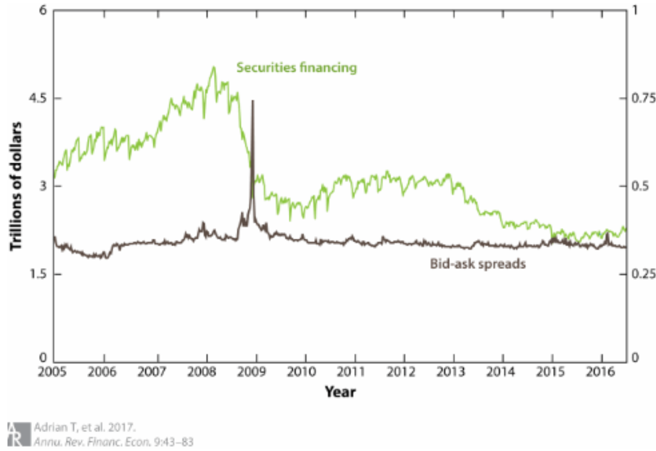
Figure 24 shows another measure of market dislocation based on the CDS-bond basis. The CDS-bond basis is calculated for investment-grade bonds as the
implied by the bond yield. The basis was close to zero, but generally positive, before the crisis; plunged to extreme negative values during the crisis before r
Boyarchenko et al. (2016) find that increased funding costs tied to balance sheet constraints are an important determinant of this apparent arbitrage oppo

A potential link between market liquidity and funding liquidity is illustrated in **Figure 25** . We use primary dealers' total financing of US Treasury securities, a
Treasury security bid-ask spreads as an indicator of market liquidity. The figure suggests that the two metrics were correlated during the financial crisis, wit
comovement, although this may reflect the fact that Treasury bid-ask spreads are often constrained by the minimum tick size, especially during normal tim
measuring funding and market liquidity, and many theoretically plausible arguments for their linkages.

Figure 25

Dealer securities financing and Treasury bid-ask spreads. This figure plots aggregate primary dealer securities financing (defined as securities out) for US Treasury securities, agency debt securities, and
ask spreads for on-the-run 2-, 5-, and 10-year Treasury notes in the interdealer market. Financing data are from the Federal Reserve's FR2004 statistical release; data on bid-ask spreads are from BrokerT



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5. CONCLUSION

Dealers' business models have changed markedly since the financial crisis, as reflected in the total balance sheet size of the dealer sector. Whereas dealers'
then stagnated, in concurrence with the deleveraging of dealers' balance sheets. Although deleveraging is an intended consequence of tighter capital regula
liquidity. Identification of causal effects is challenging, however, because the regulations were announced and implemented at a time when dealers' risk-ma
electronification of markets was increasing, and expected returns to market making were changing.

Despite the many factors affecting dealer business models, we do not uncover clear evidence of a widespread worsening of liquidity in two markets in which
market thus remained narrow and stable in the years after the crisis. Order book depth and price impact showed signs of reduced liquidity after early 2013,
market, bid-ask spreads narrowed after the crisis to levels lower than those before the crisis for retail trades, whereas trading volume and issuance increase
remained above precrisis levels in the years after the crisis. In response to three market shocks in the postcrisis era, we find that bond market liquidity rema

Our analysis therefore suggests that the postcrisis stagnation of dealer balance sheets has not markedly impaired bond market liquidity. We caution, howev
limitations. We discuss directions for future research that could potentially overcome these shortcomings. First, we review the need for additional data sour
importance of new methods for drawing inferences about liquidity in the presence of incomplete data. Third, we explain how endogeneities can lead to bias
distinctions and interactions between market liquidity, liquidity risk, and funding liquidity.

DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

ACKNOWLEDGMENTS

ACKNOWLEDGMENTS

An earlier version of this article circulated in May 2015 under the title "Vol-of-Vol and Market Making." We thank Amias Gerety, Frank Keane, Nellie Liang, Lor
Nate Wuerffel, as well as workshop and conference participants at Columbia University; the Commodity Futures Trading Commission; the Conference on th
Corporate Debt Market Structure, Liquidity and Volatility; the Fixed Income Analysts Society; the FSB Workshop on Evaluating the Post-Implementation Effe
Sacred Heart University; SIFMA; the US Treasury Department; and the University of Maryland for helpful comments. We also thank Collin Jones, Daniel Stac
writing, Erik Vogt was with the Federal Reserve Bank of New York. The views expressed in this paper are those of the authors and do not necessarily reflect t
of the Federal Reserve Bank of New York or the Federal Reserve System.

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