Is Market Liquidity Reducing? A Preliminary Case Study of US Treasuries[*]

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The US bond market is the largest in the world. According to the Securities Industry and Financial Markets Association (SIFMA), as of Q1 2017, the U.S. bond market size was US $ 39.7 trillion, of which treasuries account for US $ 14 trillion, constituting the biggest check of over 35 per cent. According to Federal Reserve Bank of New York, US treasury (primary dealer activity) average trading volume in Sept 2017 was at US $ 507 billion. The bulk of these transactions take place over the counter. The issue of financial market liquidity has come to occupy the center stage of policy concern of late. It is contended that regulatory reforms implemented in the wake of the recent global financial crisis, coupled with other developments, have contributed to the reduction of market liquidity - the ability to transact (buy and sell) in securities quickly, at any time, at minimal cost (Tobias Adrian, Michael Fleming, Daniel Stackman, and Erik Vogt, 2015). In fact, Financial Stability Board (FSB) has identified market liquidity as one of the three areas for ongoing attention regarding the effects of reforms (FSB, 2016). Therefore, the critical issue is: is there really any sustained reduction in liquidity? This paper endeavors to search for evidence for any reduction in US Treasury market liquidity, employing basis metrics of measuring liquidity, using recent data.

The paper is organized into 6 sections. Section 1 documents the extent and nature of banking prior to and the generic impact of Great Recession. Section 2 enumerates the broad contours of regulatory reforms initiated in response to the recent global financial crisis, takes stock of the status of their implementation and flags the concerns that these reforms, coupled with other developments, have impacted the market liquidity. Section 3 briefly analyses some of the recent studies on the subject. Section 4 presents the methodology employed in this paper to measure the market liquidity. Section 5 presents the evidence, while Section 6 concludes.

Section 1: Banking Prior to and Impact of Great Recession

The recent global financial crisis was in part due to excessive growth of the financial sector. In this section, it will be argued that in the run up to the GR, banking was increasingly characterized

[*] Extremely helpful guidance from Prof. Gabriel Mihalache is acknowledged with thanks.

by leveraged and growing – both in size and complexity – balance sheets, excessively reliant on short-term wholesale funding. The business model of banking was one of securitized banking. In securitized banking, pain-vanilla loans and advances on the asset-side are repackaged and sold as securitized bonds and these securitized bonds are typically used as collateral to raise more (short-term) funds on the liability-side, completing the cycle. In the securitized banking, the main source of profits is, therefore, intermediation and not holding the loans.

Growing and complex balance sheet

In the wake of 2001 recession in the US, following the dot-com bubble, the Federal Reserve steadily lowered target federal funds rate from 6 per cent to 1.75 per cent and in summer of 2003 lowered it further to 1 per cent, a 50-year low. The low federal funds rate resulted into across-the-board rate reductions for loans and mortgages. The US banks, in order to pursue aggressive growth path in an environment of easy money, low yields and intense competition, offered numerous mortgages, including exotic mortgages, initially to prime borrowers and then to sub-prime borrowers in the hope that booming real estate market will continue and the security cover will be more than adequate. Thus, there followed an unprecedented credit expansion especially in the form of mortgages. During mid-1990s, US households borrowed an annual average of about US $ 200 billion in mortgages, which suddenly rose to US $ 500 billion during 1998-2002 and to US $ 1 trillion from 2003 to 2006 (Chart 1). This sharp expansion in the balance sheet of banks was facilitated by what is called in the literature as securitized banking. The securitized banking was characterized by carving out pools of housing loan with different risk and return features on the asset-side of the balance and selling them down through innovative structures such as Special Investment Vehicles (SIVs) to various investors including banks. These pools were called Residential Mortgage-backed Securities (RMBS). RMBS typically constituted largest chunk of Asset-backed Securities (ABS). The share of mortgages that were bundled into MBSs grew from 50 per cent into 80 per cent by 2008 (Neva Gordwin, 2014). Further, the ABSs in general and RMBSs, formed the basis for re-securitization into CDOs. Thus CDOs represented "bundle of bundle" of mortgages. These securitized and re(re)securitized assets (CDO2) eventually returned to the balance sheets of the banks. Thus, the asset-side of the balance sheets of the banks was populated by those assets, valuation of which was opaque, while their liquidity was uncertain.

Chart 1: Issuance in US Capital Markets

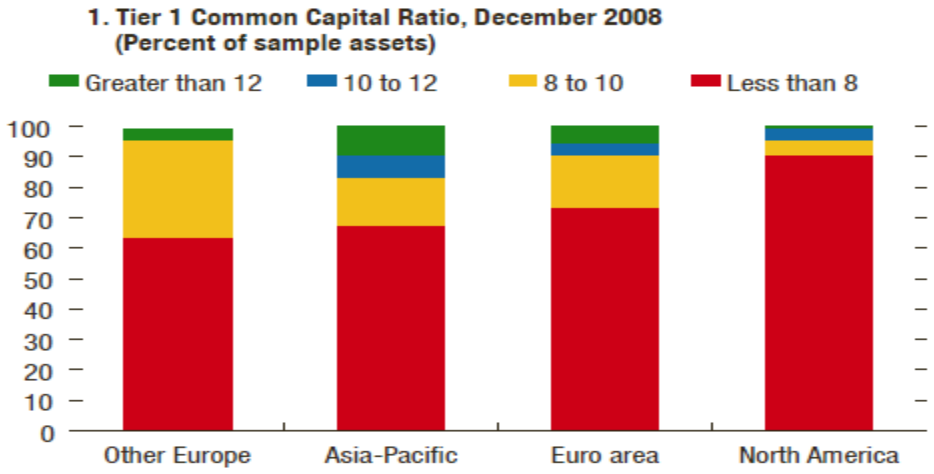
On the liability-side, these asset-purchases were financed by short-term funding through repos. While there are no official statistics about the overall size of the repo market, there are estimates that prior to the GR, it could be about US $ 12 trillion (including double counting) compared to the total assets of US banking system of US $ 10 trillion (Gorton, Gary, and Andrew Metrick, 2009). In particular, there are estimates that top investment banks in the US funded about half of their assets using repos and repo markets doubled in size since 2002, "with gross amounts outstanding at year-end 2007 of roughly $10 trillion in each of the U.S. and euro markets, and another $1 trillion in the UK repo market" (Hördahl, Peter and Michael King, 2008). Thus, the funding pattern was vulnerable to roller-risk due to market disruptions. This has exactly what happened in August 2007, when the repo market experienced freeze with haircut on the repo collateral started claiming up. By January 2009, the haircut reached as high as 45 per cent (Gorton, Gary, and Andrew Metrick, 2009). When the higher haircut dried out funding, fire asset sales ensued. As the valuation of exotic assets (CDO, CDO2, etc.) was opaque, these assets suffered acute illiquidity. Hence, the crucial cycle, referred to earlier, at the heart of the securitization banking, broke, brining entire banking business to a grinding halt.

Meager capital

Further, in the run up to the GR, banks were severely undercapitalized. As documented in the Global Financial Stability Report 2009 of International Monetary Fund (IMF), in North

America, for example, more than 90 per cent of banks had their tier-1 capital ratio at-end December 2008 below 8 per cent. The Chart 2 illustrates the point clearly.

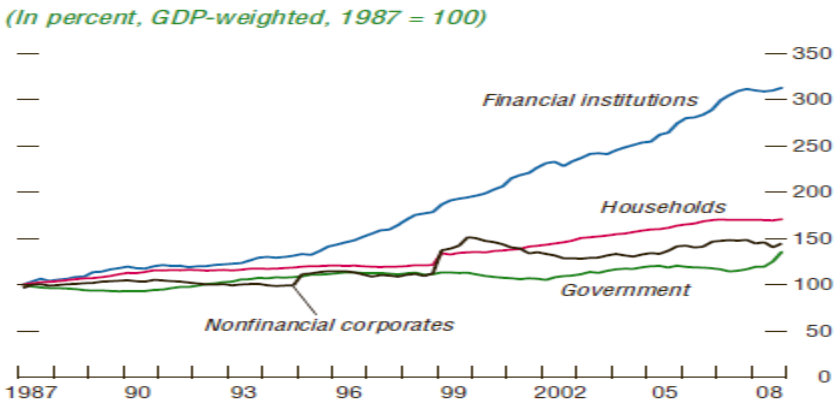
Chart 2: Capital Adequacy in 2008



High leverage

The easy monetary policy pursued in advanced economies, as alluded to earlier, encouraged excessive leveraging on the part of investor as well as banks and financial institutions. The sharp rise in the leverage of financial institutions during 2000s has been particularly striking as can be seen from the below chart, reproduced from GFSR 2009 of IMF.

Chart 3: Debt-to-GDP Ratio of Select Advanced Economies



Thus, banks entered the GR with a broken securitized banking with meager capital base, and complex balance sheets underpinned by high leverage.

"We came very, very close to a global financial meltdown" (Bernanke, 2010). These words were said by the then Federal Reserve Bank chairman in his interview with CBS's '60 Minutes'. The Federal Reserve Bank of San Francisco in its Economic Letter dated July 11, 2011 estimated that the Great Recession of 2007–2009 has led to over $7,300 in foregone consumption per person, or about $175 per person per month. In addition, there were other costs too, including adverse impacts on labor and housing markets and drop in tax revenues of the government. In particular, nonfarm payroll employment fell by about 8.5 million jobs from peak to trough. The unemployment rate rose from 4.7% in November 2007 to a peak of 10.1% in October 2009 (Lansing, 2011). The nations real Gross Domestic Product (GDP) declined five of the six quarters that made up 2008 and first half of 2009, including a losing streak of four straight quarter, the worst performance since the 1930s. To quote the abstract of a study by Federal Reserve, Dallas: "The 2007-09 financial crisis was associated with a huge loss of economic output and financial wealth, psychological consequences and skill atrophy from extended unemployment, an increase in government intervention, and other significant costs. Assuming the financial crisis is to blame for these associated ills, an estimate of its cost is needed to weigh against the cost of policies intended to prevent similar episodes. We conservatively estimate that 40 to 90 percent of one year's output ($6 trillion to $14 trillion, the equivalent of $50,000 to $120,000 for every U.S. household) was foregone due to the 2007.09 recession" (Tyler Atkinson, 2013).

Section 2: Banking Regulatory Reforms[1], Implementation and Effects

The post-crisis reforms proceeded in distinct stages. The first stage focused on immediate stabilization in the form of emergency measures, including recapitalization and central bank assistance. In the second-phase, globally concerted efforts were made to address the regulatory loopholes identified in the wake of the GR. In this section, each of these two distinct phases of banking reforms post-GR is analyzed.

Stabilization measures

Many advanced countries provided support to their financial sectors in the immediate aftermath of the crisis, though the extent and nature of such support varied. Nevertheless, broad

[1] This section draws extensively from the Global Financial Stability Report, April 2014, International Monetary Fund.

support measures assumed the form of capital injections, asset purchases and direct lending by the treasury, central bank support with or without direct treasury funding and guarantees for financial sector liabilities. According to the estimates of IMF, as on May 19, 2009 and in terms of 2008 GDP, headline support (committed but no entirely used) in advanced countries amounted to 50.4 per cent of GDP. The upfront government financing (actual outlays), however, stood at 5.8 per cent of GDP. In the US, upfront financing constituted 7.5 per cent of GDP - capital injections (4.6 per cent), asset purchases (2.3 per cent) and liquidity support with treasury baking accounted (0.7 per cent). The outlays on upfront financing in the US was distributed among the Troubled Asset Relief Program (TARP; $700 billion); government sponsored enterprise (GSE) support ($200 billion); GSE Mortgage-Backed Securities (MBS) purchase program ($124 billion) and Treasury support for Commercial Paper Funding Facility ($50 billion). Details of supports measures introduced during April – Mid-October 2009 are presented in the Appendix D (IMF, 2009).

Regulatory overhaul

The post-crisis reform plan has four core elements: reforms aimed at making financial institutions more resilient; ending too-big-to-fail (TBTF); making derivatives markets safer; and transforming shadow banking into resilient market-based finance.

- Reforms aimed at making financial institutions more resilient focused on three aspects: strengthening capital requirements for banks to enhance their lose-absorbing capacity, reducing risks involved in wholesale funding and proprietary trading to augment banks' resilience by limiting leverage and discouraging trading and mandating holding of liquid assets to increase defenses against liquidity shocks.

- A set of reforms for Systemically Important Financial Institutions (SIFIs) – Global Systemically Important Banks (G-SIBS) and Domestic Systemically Important Banks (D-SIBs) - sought to end too-big-to-fail problem by reducing the probability of failure of these large and complex financial institutions and by putting in place a robust resolution framework so that the institutions can be wound down in an orderly manner, should they fail.

- Another set of reforms are aimed at strengthening financial market infrastructures by addressing issues in the OTC derivatives markets by ensuring that the transactions in these markets are reported, centrally cleared and, where possible, settled through a central counterparty.

- Yet, another set of reforms created a system-wide monitoring framework to assess global trends and risks in the shadow banking system and developed policy measures to strengthen oversight and regulation focusing, *inter alia*, on mitigating risks in banks' interactions with shadow banking entities; reducing the susceptibility of money market funds to runs and assessing and mitigating financial stability risks posed by other shadow banking entities and activities.

Implementation and its Effects[2]

The effects of the above reforms implemented so far have been broadly positive. Firstly, banks, are significantly more resilient. Banks have built higher and better quality capital buffers, largely through retained earnings. They now have significantly lower leverage than before the crisis. All internationally active banks have fully met the Basel III capital requirements ahead of the 2019 deadline (Chart 4), while continuing to pay out dividends and engage in share buybacks. Secondly, funding profiles have improved especially for those banks most affected by the crisis, both due to less reliance on short-term wholesale funding (replaced by more stable sources, such as deposits) and as a result of having more liquid assets (particularly government bonds and, in some cases, central bank reserves). Last but not the least, business models based on high leverage, riskier trading activities and over-reliance on wholesale lending and funding have diminished, as intended, and are being replaced by models with a greater focus on retail banking (Chart 5). Banks are also shrinking less profitable business lines and some of them have scaled back foreign activities (FSB, 2016).

[2] This section draws extensively from FSB, 2016

Chart 4: Capital Ratios

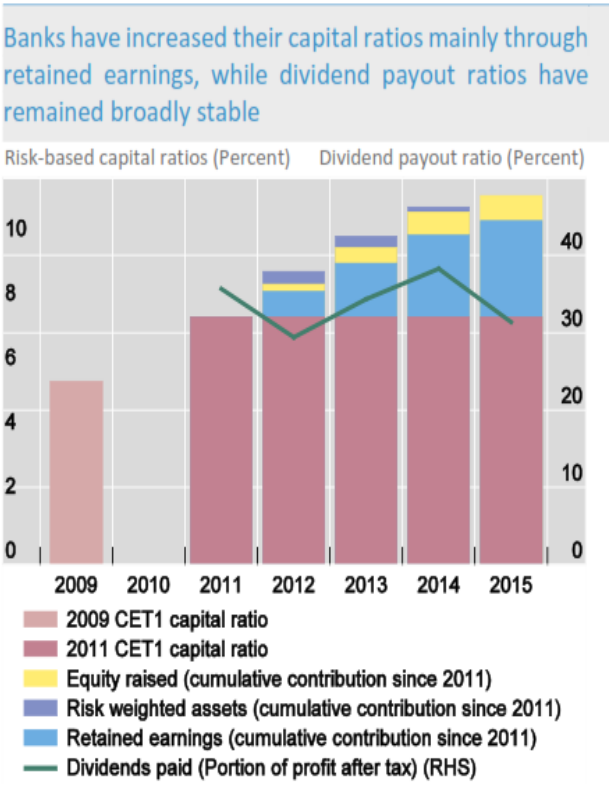
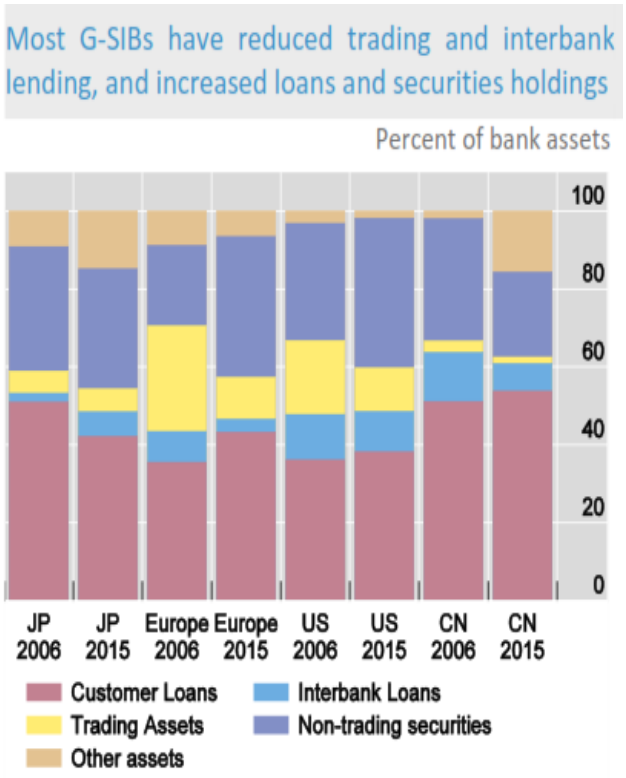


Chart 5: Changing Business Models of Banks



Exceptionally accommodative monetary policies may also have contributed to the above outcomes, reducing banks' exposure to market fluctuations and susceptibility to runs. The magnitude of accommodation from the ultra-loose monetary policy stance could be gauged from the expansion of balance sheet of systemically important central banks[3]. From December 2007 to May 2017, the Fed's total assets increased from $882 billion to $4.473 trillion—a fivefold increase, meaning total Fed assets increased from 6.0 percent of U.S. GDP in the fourth quarter of 2007 to 23.5 percent of GDP in the first quarter of 2017. In December 2016, the Bank of Japan had a balance sheet pf the size of 88 percent of GDP; Switzerland's, 115 percent of GDP; the Swedish Riksbank's, 19 percent of GDP; the Bank of England's, 24 percent of GDP and the European Central Bank's, 34 percent of GDP (Stephen Williamson, 2017). These accommodative monetary conditions have also likely eased market liquidity across many fixed income markets (FSB, 2016). Additionally, technological progress and competition have also brought in many more structural changes as the trading activities are increasingly shifting towards automation in terms of execution and clearing.

[3] Expansion of central bank balance sheet means increasing primary liquidity/monetary base leading to rise in money supply

Further, progress has also been noticed in strengthening the resilience of financial markets, as opaque and complex securitisations have dropped reflecting increased risk awareness and stronger regulation and OTC derivatives contracts are increasingly cleared by central counterparties (CCPs) to reduce contagion risk among market participants.

This improved resilience of banks and markets has been achieved while maintaining the overall provision of credit to the real economy. Off-take of credit has improved across the regions, though at varying pace with cost of borrowing broadly remaining low, aided by exceptionally accommodative monetary policies.

While technological innovations and regulatory changes represent structural factors, monetary policy developments embody the conjectural factors. These structural and conjectural factors are causing changes in market liquidity. Regulatory reforms to make banks more resilient have increased the costs of dealer banks' market-making activities, including liquidity provision. Less abundant liquidity in normal times was a recognised cost of building more resilient banks. On the other hand, however, the technological and regulatory changes that enhance market transparency, have helped reduce average trading costs and mitigate the impact of reduced liquidity provision by traditional market makers. Nonetheless, these changes may imply that market prices react more strongly and quickly to order flow information, adding to the difficulties involved in trading large amounts and contributing to the decline in depth in some markets (CGFS, 2015). In response to these discernible concerns for market liquidity arising out, *inter alia*, of regulatory reforms, in November 2014, the Committee on the Global Financial System (CGFS) published a report on the current trends and drivers of market-making and proprietary trading in fixed income markets (CGFS, 2014). The report pointed to signs of increased liquidity bifurcation and fragility, with market activity concentrating in the most liquid instruments and deteriorating in the less liquid ones.

As a follow up, the CGFS published its updated assessment of unintended impact of regulatory reforms on market liquidity (CGFS, 2015). Further, one of the three areas identified by FSB for ongoing attention regarding the effects of reforms is market liquidity. Additionally, there have been a few studies aimed at evaluating the impact of these regulatory reforms on market liquidity and these are discussed in the next section.

Section 3: Literature Review

Liberty Street Economics blog of Federal Reserve Bank of New York has commenced a series on market liquidity. The blog kicked off the series by publishing 5 posts shedding light on the evolving nature of market liquidity, with the first post examining various measures of liquidity in the Treasury market. The authors of the post used both high frequency measures and the daily measures. While high frequency liquidity measures included bid-ask spread, order book depth[4] price impact of trades, and trade size, daily measures consisted of measuring average absolute difference between actual yields and predicted yield[5] and Refcorp spread[6]. Overall, the evidence presented in the post is broadly sanguine about the market liquidity in US treasury. Direct measures such as the bid-ask spread indicated ample liquidity, other measures such as quote depth and price impact implied some recent deterioration in liquidity, albeit from unusually liquid conditions. The broad evidence suggested that concerns for market liquidity didn't emanate from the market for benchmark Treasury notes (Tobias Adrian, Michael Fleming, Daniel Stackman, and Erik Vogt, 2015). BIS observed that liquidity conditions in sovereign bond markets measured by price-based metrics such as bid-ask spreads, remained little changed, though quantity-based metrics, by comparison, pointed to somewhat diminished market depth and transaction sizes (CGFS, 2015). Similar inferences were made by DTT[7] in its Discussion Paper on the subject (DTCC, 2016). Fender and Lewrick found evidence that liquidity conditions in sovereign bond markets returned to those prevailing during pre-crisis period measured by bid-ask spreads, trading volume and the average size of transactions and price impact co-efficient. However, corporate bond markets have become less liquid, leading to what is called liquidity bifurcation (Fender, Ingo and Lewrick Ulf, 2015). While these studies broadly concurred that liquidity in sovereign band markets remained intact, judged at least by price-based matric, they are dated in the sense that they don't cover the recent period. However, there have been growing concerns that of late, market liquidity has suffered. This paper attempts to revisit and re-assess the liquidity in US treasury markets using the

[4]Indicates the average quantity of securities available for sale or purchase at the best bid and offer prices),
[5]The absolute difference indicates unexploited profit opportunities, reflecting constraints on market making capacity and/or poor liquidity.
[6] The yield spread between bonds of the Resolution Funding Corporation and Treasury securities with similar cash flows.
[7] A leading financial services provider.

latest data. The next section discusses the methodological approach used in this paper for the purpose.

Section 4: Methodology

A liquid market is the one which is characterized by low cost involved in executing trades. There is no single measure of market liquidity (Fleming J, Michael , 2003). Broadly, there are price and quantity based measures. While bid-ask spread and price impact are the price-based metrics, trading volume and frequency, quote size and trade size are some of the quantity based measures.

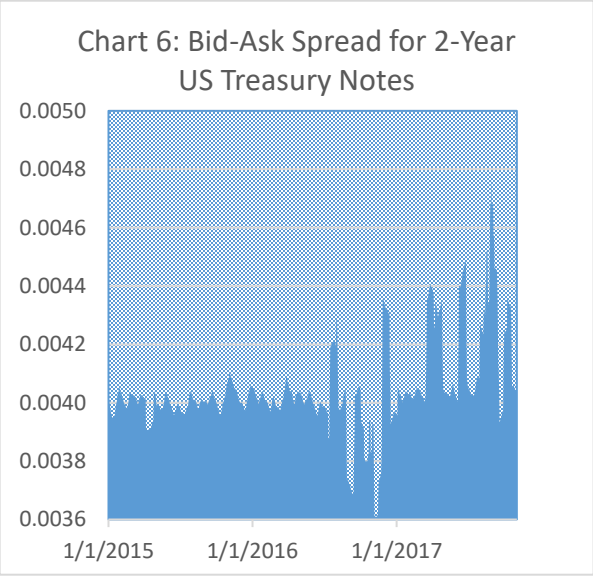
The bid-ask spread is a commonly used measure of market liquidity. It measures the cost of executing a trade, with the cost typically computed as the difference between the bid and offer prices. Another popular measure of liquidity is called price impact coefficient and it relates net trading activity to price changes. Less liquid markers typically tend to exhibit larger price changes for a given change in net trading activity. In the literature, it's known as *the Kyle lambda* and is defined as the slope of the line that relates the price change to trade size. The quantity of securities that is explicitly bid /traded at the bid and offer prices indicates the depth of the market, and is called the quote size. Higher the quote size, higher the liquidity and *vice versa*. An alternative metric of liquidity is trade size. Trade size is an ex-post measure of the volume of securities traded at the bid or offer price; higher trade sizes imply better liquidity and *vice versa*. Trading volume is yet another quantity-based measure and markets with high trading volumes tend to be more liquid. A closely related measure of quantity-based liquidity is trading frequency. Trading frequency denotes the velocity of number of trades executed within a given period of time. Like trading volume, high trading frequency may typify a more liquid market.

Among these measures, which is the superior metric? Though, there is no single yard-stick to rank the measures, there are however broadly 3 ways in which the measures could be evaluated. Firstly, it should be directly able to quantify the cost associated with executing trades. Secondly, it should consistently reflect the market participants' views about the market liquidity. Finally, it should be easy to calculate and understand and be available to market participants on real time basis. On all these counts, bid-ask spread scores superior. Further, in the literature, there is evidence that bid-ask spread is highly correlated with the most sophisticated metric of price impact

and most of the quantity based indicators of market liquidity, especially, quote size and trade size, meaning higher quote sizes and higher trade sizes are associated with narrower bid-ask spreads. Thus, bid-ask spread is a useful measure for assessing and tracking liquidity (Fleming J, Michael , 2003). Accordingly, drawing from the literature, in this paper, bid-ask spreads are calculated for a period of 3 years based on the daily data from January 1, 2015 to November 2, 2017 for 2-year, 5-year and 10-year US treasury notes. The data is sourced from Bloomberg. The spreads are thus calculated and the 21-day moving average of the spreads for the above said benchmark Notes are analyzed to evaluate market liquidity conditions. Further, a simple regression analysis with various model specifications (See Annex) is performed using data on spread for 2-year US Treasury Note to evaluate impact of post-crisis regulatory reforms on market liquidity for US Treasury Notes. The empirical results are presented in the next section.

Section 5: Empirical Results

Chart 6 presents the 21-day moving average bid-ask spread for the 2-year US Treasury Note since Jan 1, 2015. It can be observed that till mid July 2016, the spread was broadly narrow and stable. However, there was a brief period in August 2016 when the spread widened, followed by a significant compression of spread in Sept and Nov 2016. Post-November 2016, there have been bouts of spikes with August 2017 witnessing sharp widening in spread. Chart 7 presents 21-day moving standard deviation of the 2-year spread. As can be observed from Chart 7, July 2016 onwards, the volatility of 2-year spread has significantly increased with June 2017 recording the highest volatility.



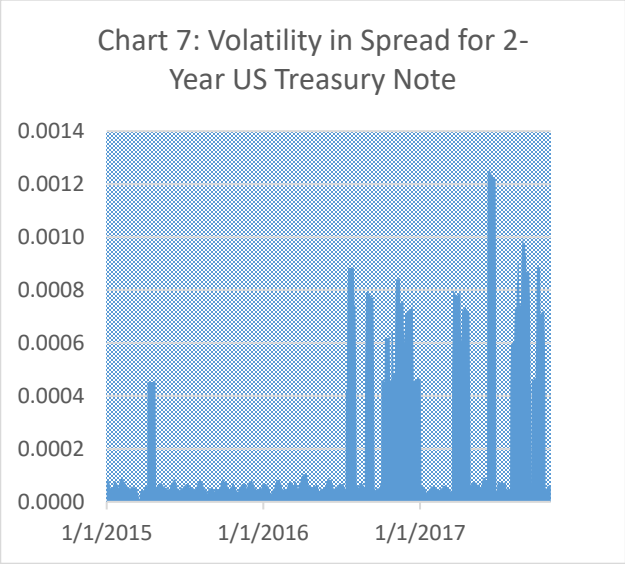
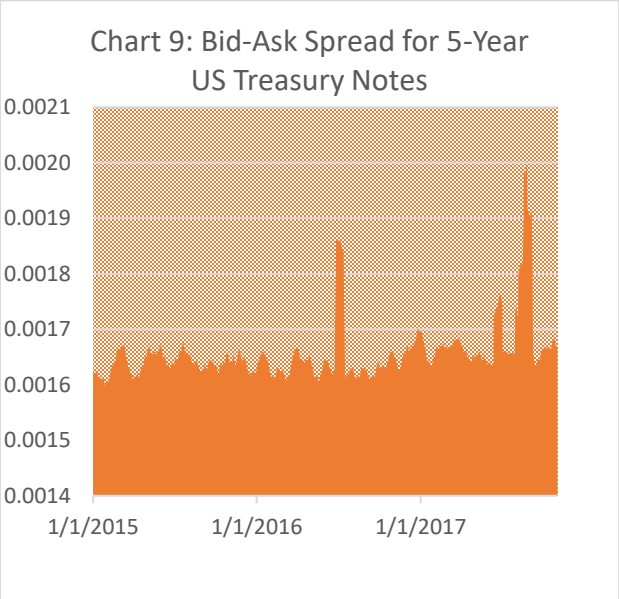


Chart 8 presents 21-day moving average bid-ask spread for 5-year US Treasury Note since Jan 1, 2015. In the previous three years, the spread has been narrow and stable but for 3 episodes of bouts of spikes in July 2016, June 2017 and August 2017. These episodes of spike in spread coincide with episodes of high volatility in spread measured by 21-day moving Standard Division as presented in Chart 9.



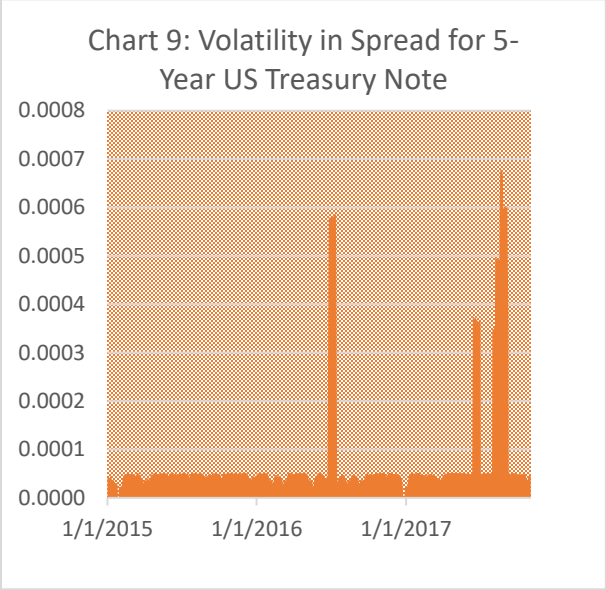
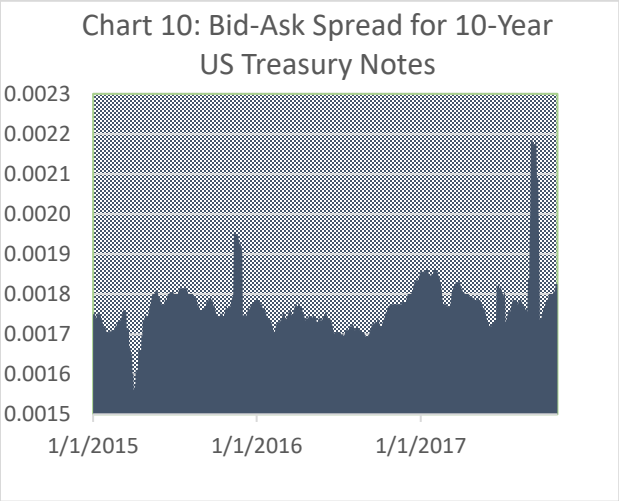
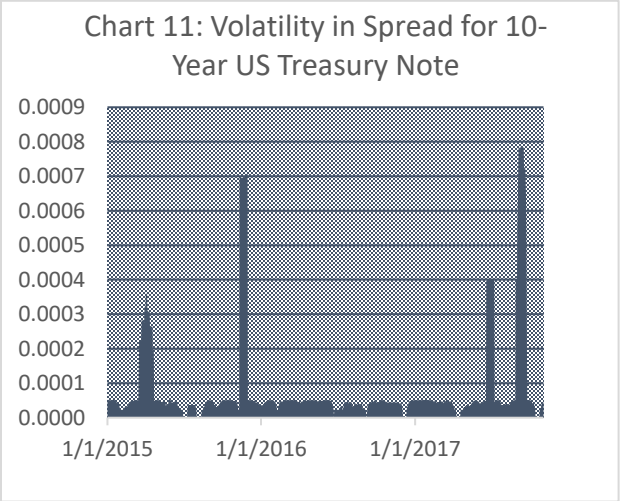


Chart 10 presents 21-day moving average bid-ask spread for 10-year US Treasury Note since Jan 1, 2015. There were two bouts of spikes in spread during Nov 2015 and September 2017. In addition, there was a phase of sustained widening of spread during Sept 2016 to Jan 2017. Broadly, these episodes reflect spikes in spread volatility as measured by the 21-day moving Standard Deviation presented in Chart 11.





The above analysis of bid-ask spread for 2-year, 5-year and 10-year US Treasury Notes underscore the fact that though bid-ask spread for the benchmark US Treasury Notes broadly remained narrow and stable, the recent data, especially for the current 2017, point to signs of market liquidity getting adversely impacted evidenced by episodes of spikes in spreads and increasing spread volatility, especially in the case of 2-year US Treasury Note.

In order to evaluate whether there was any significant impact of regime change represented by post-crisis regulatory reforms on market liquidity in US Treasury market, a simple regression analysis is performed using bid-ask spread for 2-year US Treasury Note. For the regression analysis, daily data period starts from July 2009 (when NBER declared the Great Recession to be over) to November 2017. However, there is a large and obvious structural break in the spread post 5/5/2011, which is controlled with a dummy (Level Dummy). As post-crisis regulatory reforms were more or less phased in by October 2016, October 1, 2016 signifies the time point for regime change, which is represented by regime dummy (RD). The simple OLS regression results with spread as dependent variable are presented in Table 1 below:

Table 1: OLS Results
Period: 7/1/2009 – 11/2/2017
No. of Obs: 3047

	Co-efficient	t-value	P-value
Constant	.0080392	548.18	0.000
LD	-0.0040113	-235.29	0.000
RD	0.0000697	3.53	0.000
Adj R^2 = 0.95			

LD is Level Dummy signifying structural level change in spread on May 5, 2011
RD is Regime Dummy signifying regime (Pre and Post crisis regulatory reforms) change in Oct 2016

As can be observed from the results presented in Table 1 above, spread had increased, on average, by 7.0E-5 (0.00007), which is statistically significant. Allowing for auto –correlation didn't change the point estimate of regime change impact on spread obtained by OLS.

Table 2: ARIMA Regression Results
(Period: 7/1/2009 - 11/2/2017; No. of Obs: 3047)

	Coefficient	Z Value	P Value	
LD	-0.004011	-103.46	0.000	Wald Chi^2 = 50347.28 Prob > Chi2 = 0.000
RD	0.0000696	2.58	0.010	
Constant	0.0080389	191.76	0.000	
AR(1)	0.388223	83.61	0.000	

Results are also robust to allowing for a moving average dynamic. Point estimate essentially unchanged as can be seen from the results presented in Table 3 below.

Table 3: ARIMA Regression Results
(Period: 7/1/2009 - 11/2/2017; No. of Obs: 3047)

Spread	Coefficient	Z Value	P Value	
LD	-0.0040112	-128.61	0.000	Wald Chi^2 = 38783.07 Prob > Chi2 = 0.000
RD	0.0000697	3.25	0.001	
Constant	0.0080391	241.52	0.000	
MA(1)	0.3060796	64.31	0.000	

Allowing for endogenously higher volatility in times of high spread yields an effect of comparable average magnitude of increase of 6.0E-5 in spread as can be observed from the Table 4 below. However, the estimation is numerically unstable if a longer sample, pre-5/5/2011, is included.

Table 4: ARCH Family Regression ARCH(1)
(Period: 5/5/2015 – 11/2/2017; No. of Observations: 913)

	Spread	Coefficient	Z Value	P Value	
	RD	0.000061	1.69	0.090	Wald Chi^2 = 2.87 Prob > Chi2 = 0.0903
	Constant	0.0040092	120.01	0.000	
ARCH	ARCH (1)	0.4405406	3.99	0.000	
	Constant	1.10e-07	92.26	0.000	

Allowing for both time-varying volatility and an autoregressive structure yields results, presented in Table 5 below, which are at odds with the above results: the sign inverts, even though the coefficient is still significant. The magnitude is again small.

Table 5: ARCH Family Regression: AR(1)-ARCH(1)
(Period: 5/5/2011 – 11/2/2017; No. of Observations: 913)

	Spread	Coefficient	Z Value	P Value	
	RD	-0.000613	-26.75	0.000	Wald Chi^2 = 3932.78
	Constant	0.0040448	951.41	0.000	Prob > Chi2 = 0.000
	AR(1)	0.5649248	48.07	0.000	
ARCH	ARCH (1)	2.270445	32.31	0.000	
	Constant	2.99e-08	143.97	0.000	

Empirical Results with Narrower Time-Windows

The results presented above are based on larger time-windows spanning the period beginning July 1, 2009. In this section, an attempt is made to investigate whether empirical results are robust to the shorter window of time as the post-crisis regulatory reforms were implicated in a gradual and calibrated manner over the years. Accordingly, estimates were generated for various narrower time-windows around the regime change/policy change. As mentioned earlier, in this paper, the time point for regime change is identified as October 1, 2016. The various narrower time windows employed for this investigation are: one week before and after, 2 weeks before and after, 4 weeks before and after and 1 year before and after October 1, 2016. The results are presented in Table 6 below.

Table 6: Empirical Results for the Narrower-Time Windows

OLS				
Window	N	Coefficient	S.D.	P-Value
+/- 1 Week	15	-0.0003036	0.0002666	0.275
+/- 2 Weeks	29	-0.0003167	0.0001896	0.106
+/- 4 Weeks	57	-0.0002288	0.0001213	0.064
+/- 1 Year	731	0.0001213	0.0000369	0.001
AR(1)				
Window	N	Coefficient	S.D.	P-Value
+/- 1 Week	15	-0.0003149	0.0011493	0.784
+/- 2 Weeks	29	-0.0003237	0.0009576	0.735
+/- 4 Weeks	57	-0.0002300	0.0006858	0.737
+/- 1 Year	731	0.0001249	0.0000919	0.174
MA(1)				
Window	N	Coefficient	S.D.	P-Value
+/- 1 Week	15	-0.0003243	0.0009472	0.732
+/- 2 Weeks	29	-0.0003313	0.0007302	0.65
+/- 4 Weeks	57	-0.0002304	0.0006761	0.733
+/- 1 Year	731	0.0001217	0.0000652	0.062

The results for the shorter time-windows are not only statistically insignificant but also have a pervert sign because of the fact that narrower-windows have too few observations to pick up the effect, but that if the window is large enough (+/- 1 year) then results are closer to the full sample. These findings reflect the fact that the policy of regime change would be expected to impact markets with some lag, since it will take time for banks to adjust their operations to the new rules and requirements.

The broader inference that can be drawn from the above results is: The regulatory reforms seem to have induced an economically-insignificant, though statistically significant, decrease in liquidity and an equally insignificant increase in volatility of bid-ask spreads. Therefore, the post-crisis regulatory reforms, aimed at ensuring resilience of banks, don't seem to have caused any significant reduction in market liquidity at least for 2-year US Treasury Notes.

Section 6: Policy Issues[8]

The findings presented in the previous section of the paper are indicative in nature, given the fact that the results are based on one, though most useful, metric: bid-ask spread. There is an imperative to assess market liquidity conditions using many other measures to get possible corroborative evidence, which is outside the scope of this paper, given the difficulty in getting the relevant data. Further, the changing liquidity conditions documented in this paper are of recent origin. Market liquidity conditions will have to be monitored on a real time basis going forward to understand the structural trends therein. Notwithstanding these qualifications associated with the findings of this paper, some of the policy issues of relevance in this regard include the following:

A key determinant of market liquidity is the thrust in the quality of traded security. If the quality of the security is perceived to have deteriorated, liquidity gets adversely impacted, as was clearly demonstrated in the recent global financial crisis. Therefore, at a fundamental level, it is indeed essential that the intrinsic value of the asset is preserved by addressing the underlying credit risk and such intrinsic value is easily assessable through enhanced transparency. In addition, policy responses to the findings presented above could broadly be visualized into two categories: *supporting initiatives* aimed at creating liquidity conditions, which are more accurately priced and robust; and *possible backstops* building safety nets against potential vulnerabilities under adverse scenarios.

As regards supporting initiatives, among others, there is a need to improve liquidity risk management of market participants focusing on liquidity stress tests by incorporating the impact of herding. In order words, liquidity stress tests should dispel what is called liquidity illusion – overestimation of market liquidity – by incorporating the fact that liquidity could become fragile if herding towards exit occurs on a large scale at any given time. Further, impact of automated, algorithm-based short-term oriented trading needs to monitored closely to mitigate any potential impact on market liquidity.

Regarding the possible backstops, central bank liquidity provision without creating any adverse moral hazard continues to be the option. But the challenge is to strike the balance between providing lender of resort services in vulnerable situations while not aggravating potential moral hazard.

[8] This section is sourced from Fender and Lewrick, 2015 and CGFS, 2015

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Appendix D. British, U.S., and European Central Bank Operations, April to Mid-October 2008

	Bank of England	Federal Reserve	European Central Bank	Coordinated Central Bank Announcements
May	Announced that expanded three-month long-term repos would be maintained in June and July.	Expanded size of Term Auction Facility (TAF). Extended collateral of Term Securities Lending Facility (TSLF).		Expansion of agreements between Federal Reserve and European Central Bank.
July		Introduced 84-day TAF. Primary Dealer Credit Facility (PDCF) and TSLF extended to January 2009. Authorized the auction of options for primary dealers to borrow Treasury securities from the TSLF.	Announced that it would conduct operations under the 84-day TAF to provide US dollars to European Central Bank counterparties. Announced that supplementary three-month longer-term refinancing operations (LTROs) would be renewed in August and September.	
September	Announced that expanded three-month long-term repos would be maintained in September and October. Announced long-term repo operations to be held monthly. Extended drawndown period for Special Liquidity Scheme 9SLS).	Expanded collateral of PDCF. Expanded size and collateral of TSLF. Announced provision of loans to banks to finance purchase of high quality asset-backed commercial paper from money market mutual funds.	Announced six-month LTROs would be renewed in October, and three-month LTROs would be renewed in November and December. Conducted Special Term Refinancing Operation.	Expansion of agreement between Federal Reserve and European Central Bank. Establishment of swap agreements between Federal Reserve and the Bank of England, subsequently expanded. Bank of England and European Central Bank, in conjunction with the Federal Reserve, announced operation to lend U.S. dollars for one week, subsequently extended to scheduled weekly operations.

	Bank of England	Federal Reserve	European Central Bank	Coordinated Central Bank Announcements
October	Extended collateral for one-week U.S. dollar repos and for three-month long-term repos. Extended collateral of all extended-collateral sterling long-term repos, U.S. dollar repo operations, and the SLS to include bank-guaranteed debt under the UK Government bank debt guarantee scheme. Announced Operations Standing Facilities and a Discount Window Facility, which together replace existing Standing Facilities.	Announced payment of interest on required and excess reserve balances. Increased size of TAFs. Announced creation of the Commercial paper Funding Facility.	Increased size of six-month supplementary LTROs. Announced a reduction in the spread of standing facilities from 200 basis points to 100 basis points around the interest rate on the main refinancing operation. Introduced swap agreements with the Swiss National Bank.	Announced schedules for TAFs and Forward TAFs for auctions of U.S. dollar liquidity during the fourth quarter. European Central and Bank of England announced tenders of U.S. dollar funding at 7-day, 28-day, 84-day maturities at fixed interest rates for full allotment. Swap agreements increased to accommodate required level of funding.

Source: *Financial Stability Report*, October 2008, the Bank of England. p. 18.

Annex

Model Specifications for Regression Analysis

Model 1 OLS	$y_t = \alpha + \beta x_t + \epsilon_t$	
Model 2 AR(1)	$y_t = \alpha + \beta y_{t-1} + \gamma x_t + \epsilon_t$	Value in current period depends on constant plus value of previous period
Model 3 MA(1)	$y_t = \alpha + \beta \epsilon_t + \gamma \epsilon_{t-1}$	Value in current period is equal to a constant plus a moving average of current and past error terms
Model 4 ARCH(1)	$y_t^2 = \alpha + \beta y_t^2 + \epsilon_t$	Volatility in current period is related to its value in the previous period plus error term. If β is positive, volatility was high in previous period, it will continue to be high in current period, indicating volatility clustering

Where y_t is spread and x_t is dummy