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SPEECH

Market Structure and Liquidity in the U.S. Treasury and Agency Mortgage-Backed Security (MBS) Markets

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Good morning, it is a pleasure to speak before the Mortgage Bankers Association today on the topic of market structure and liquidity. Please note that my remarks reflect my personal views on these topics and not necessarily the views of the Federal Reserve Bank of New York or the Federal Reserve System.[1]

Fixed income market liquidity has garnered substantial attention from market participants, the media, and policymakers in recent years. There has been a notable amount of market commentary suggesting deterioration in liquidity, yet it has been difficult to find compelling evidence for this in many traditional indicators used to measure liquidity. Why might this be the case? Market liquidity is central to the functioning of financial markets, and a sustained examination of this topic should remain a priority for private market participants as well as the public sector.

Today I'd like to focus on the interaction of liquidity and market structure in the Treasury and agency MBS markets as offering some important insight into this question. We should expect liquidity conditions to be dynamic, changing as the structure of markets change, including the instruments, participants, practices and policies that impact trading across financial markets. The Treasury and agency MBS markets in particular have each been undergoing significant structural changes that have implications for the way that we measure and interpret liquidity conditions now and in the future. Indeed, market structure changes may help explain why the market narrative on liquidity at times appears to diverge from some of the traditional measures.

What are the linkages between liquidity and market structure in the Treasury and agency MBS markets?

The Treasury and agency MBS markets represent the largest, most liquid government securities markets in the world. The Treasury market comprises over $13 trillion in marketable securities, while the amount of outstanding agency MBS is nearing $6 trillion. About $500 billion in Treasuries trade hands every day, and agency MBS volumes represent another $200 billion in daily trading.[2]

This immense liquidity is important for the health of financial markets and the economy. Liquidity in the Treasury market is essential to the market's vital role in global financial markets, lowering financing costs to the U.S. government, contributing to the market's use as a risk free benchmark, and allowing Treasury securities to serve as an important store of value and means of managing risk for investors. In the mortgage market, a well-functioning secondary market allows mortgage market participants to manage their risk, and helps lower the cost of home ownership. For the Federal Reserve, these markets are important because of their role in the implementation of monetary policy. We conduct open market operations that rely on and interact with liquidity in these markets, like the large scale asset purchases and reinvestments. We also analyze these markets to help understand monetary policy expectations, and how financial conditions and structure are changing.

How did these markets become so liquid and vital? Were their structures determined by historical accident, or was it by clever design? A number of scholars and analysts have studied these markets in depth, including the evolution of their instruments, participants, practices and policies—all elements of what I will define as being "market structure."[3] I won't be able to do justice to their work in this discussion. But suffice it to say that historical evolution, innovation, and important private- and public-sector policy choices along the way have shaped these markets in ways that help them serve the public and private sectors very well.

On the policy side, decades ago Treasury developed the practice of prioritizing a 'regular and predictable' approach to holding auctions, a change which helped develop secondary market liquidity across the curve of maturities, and is widely credited with reducing uncertainty and minimizing government borrowing costs.[4]

The Treasury market has been undergoing rapid change in the last decade, as explored in detail in a Joint Staff Report on the events of October 15, 2014, when the Treasury market experienced what is sometimes called a "flash rally."[5] For example, the interdealer market has evolved into high speed electronic central limit order books, or CLOBs, that play a key role in Treasury market price discovery. As it has in equities, futures and foreign exchange markets, the shift towards electronic and automated

trading has reduced the costs of trading and enhanced many dimensions of liquidity by enabling a greater number of market participants to trade in a more efficient manner.[6]

The agency MBS market traces its roots back to 1970 when the first Ginnie Mae mortgage-backed security was issued. By pooling several loans into a tradable security, and guaranteeing the timely receipt of principal and interest, Ginnie Mae created a tradable mortgage instrument that was attractive to a wide variety of global investors. Soon afterwards, the development of the To-Be-Announced (TBA) market allowed for fungible forward-trading of what is today millions of otherwise less liquid individual securities. Roughly 90 percent of the of agency MBS trading occurs in the TBA market, making it the second most actively traded fixed income market behind Treasuries in the United States. The combination of the agency guarantee and the TBA market structure has been estimated to lower mortgage rates by as much as 50 basis points and this benefit can be higher during periods of stress.[7]

Frictions and risks in these markets can also highlight the importance of market structure. For example, when interest rates fell close to zero around the time of the financial crisis, the Treasury and agency MBS markets experienced heightened levels of settlement fails. In response, the Treasury Market Practices Group (TMPG)—a private sector group of market professionals dedicated to the integrity and efficiency of the Treasury, agency debt and agency MBS markets—responded by recommending a charge for fails in the Treasury market and later the agency debt and MBS markets.[8] These charges led to a sharp reduction of fails and improvement in market functioning.[9] A few years later, the TMPG took steps to improve market functioning by recommending margining for forward-settling agency MBS transactions.[10] The TMPG's efforts have removed obstacles that would otherwise undermine market functioning, and helped identify practices that have improved the integrity and liquidity of these markets.

Whether policy choices, or the innovation of practices and technology, these developments provide us with insights into the relationship between liquidity outcomes and characteristics of market structure. For example, it appears that liquidity is generally enhanced where trading:

- is concentrated in a limited number of instruments with a high degree of standardization;
- involves a large and diverse group of participants;
- uses common and efficient trading practices, frequently that are electronic; and
- is guided by private- and public-sector policies that contribute to the integrity and efficiency of markets.

Where these conditions exist, liquidity tends to be higher on average: trading is faster and less costly, depth is greater and prices are more efficient. When they do not exist, liquidity tends to be lower: trading is slower and more expensive, with less depth and efficiency.

Why do market structure changes make understanding liquidity in these markets challenging?

Let me start by laying out a definition of liquidity.

Liquidity can be a fairly abstract concept and there are numerous ways to define and measure it. The definition I prefer is this:

Market liquidity is the cost of quickly converting a desired quantity of an asset into cash (or cash into an asset) at an efficient price.

The definition incorporates four components. First, cost. What is the transaction cost of executing a trade? Second is timeliness. How quickly can you get in or out of a position? Third is depth. What quantity can be bought or sold at a given price? And finally, efficiency. Are trades conducted at efficient prices?

Price efficiency is not usually included in the definition of liquidity, but the concept seems quite important, especially in a world of high-speed electronic markets and a higher incidence of "flash" events. Low transaction cost and quick execution may mean little if the price at which a transaction is conducted is at a level that defies common sense or is obviously artificial.[11] A number of flash events in different asset classes provide recent examples of this concern, including the equity markets in May of 2010, the Treasury market in October of 2014, and foreign exchange markets in March of 2015. In each of these cases, there was no new information that could have changed the value of these assets so dramatically, especially in such a rapid fashion, but nevertheless the stocks of some healthy companies traded briefly at pennies, major foreign exchange pairs whipsawed, and the prices of the world's preeminent risk-free assets experienced historic moves, including an unprecedented 16 basis-point round-trip in the 10-year Treasury security that spanned just a few minutes amidst the fourth-largest intraday trading range in close to two decades. During each of the events, trading volume surged, market depth fell, and realized volatility spiked, as market participants seeking to manage their exposures and liquidity risk amplified price movements.[12] Despite these signs of illiquidity, in flash events bid-ask spreads often remain narrow, and price movements can be fairly continuous.[13]

Flash events thus might be characterized as a modern form of illiquidity in which transactions in highly automated markets may still take place quickly—sometimes on the order of microseconds—and even at narrow bid-offer spreads, and yet broader liquidity

conditions deteriorate significantly, with buyers and sellers no longer transacting at efficient prices. Notably, while traditional market makers report that days like October 15, 2014 are highly unusual, many firms employing high-speed automated trading report that such days do not necessarily require them to adjust their algorithms, and they may even see the events as relatively slow-moving. These divergent perspectives and the increased incidence of flash events across markets might foreshadow an increase in market liquidity "jump" risk—the risk of a sudden and large jump in prices or volatility—a concern for which there is some evidence.[14] More work must obviously be done to better understand the financial stability risks associated with flash events.

Given the multidimensional nature of liquidity that I've just described, quantifying liquidity can be challenging, but there are a number of measures market participants use to monitor dimensions of market liquidity over time. In the Treasury market, analysts frequently look at measures like bid-ask spreads to discern the cost of trading, which is often supplemented with other measures, like order book depth and price impact measures, that evaluate how trade sizes and price changes are related. To gauge market efficiency, market participants often use measures like yield curve fitting errors, which measure the dispersion of traded yields around a smoothed yield curve. Overall, measures of liquidity in the Treasury market appear to paint a somewhat mixed, albeit largely positive, picture of market liquidity, with bid-ask spreads stable and price impact well within historical ranges. Some measures, including yield curve fitting errors, show some deterioration in recent years, but with levels near longer-run averages (Exhibits 1-3).[15]

For mortgage-backed securities, some cost metrics like quoted bid-ask spreads are less useful because they come from dealer-to-customer platforms and capture only the likely, or "indicative," price at which a transaction might occur. As a result, analysts focus on measures of activity such as trading volume, trade size and turnover rate in addition to derived bid-ask spreads based on actual transaction prices and other indicators, such as price impact. Like the Treasury market, most measures of liquidity conditions have declined somewhat in recent years, but levels are at or near long run averages. For example, average trading volume and average trade size have each declined from the high levels witnessed just before and after the crisis, but are consistent with levels seen in the early part of last decade, while measures of bid-ask spreads and price impact suggest that liquidity conditions are relatively stable (Exhibits 4-6).[16]

Despite this relatively benign backdrop, market participants have consistently described liquidity conditions as increasingly challenged, with many quick to point out that traditional measures of liquidity may not be indicative of actual trading conditions. Traditional liquidity metrics only capture trades that have taken place, but do not capture the immediacy with which participants were able to trade, or if they were able to trade at all. Furthermore, firms report having had to change their market making operations in response to liquidity conditions, with many pointing out that they can no longer trade in the size that they have in the past without impacting market prices.

So if liquidity conditions seem to have changed, why is it not obvious in traditional measures?

Changing market structure provides at least some insight to this question. Structural changes mean that our interpretation of some liquidity measures must adapt, and that we may also need to search for new ways to measure liquidity. In other words, both the interpretation and measurement of liquidity must evolve as market structure evolves. To illustrate this point, I'd like to describe three important ongoing changes in fixed income market structure that help us reconcile aspects of the narrative around liquidity and what we see in the data. These include: (1) electronic and automated trading; (2) bank regulation and risk management; and (3) evolving public sector ownership.

Electronic and Automated Trading

I mentioned earlier that bid-ask spreads in Treasury markets have been low and stable in recent years, which most would interpret as a positive indicator for liquidity. But it is no longer clear that we can take a strong signal about liquidity from bid-ask spreads in the interdealer Treasury market. The growth of high-speed automated market making in interdealer Treasury markets has dampened variation in this measure as firms employing these strategies tend to provide narrow bid-ask spreads, even during volatile times and "flash" events. However, high speed market makers often respond to instances of elevated volatility by rapidly reducing the quantity they are willing to buy or sell at a given price, resulting in lower market depth, suggesting that measures that incorporate depth and its volatility may prove more important in highly automated markets. Some refer to this aspect of liquidity as creating a "liquidity illusion" or "phantom liquidity," as it can disappear suddenly. On October 15, 2014, as noted in the Joint Staff Report, bid-ask spreads moved very little throughout the day, but market depth was volatile and dropped to very low levels just before the round-trip in prices (Exhibits 7 and 8).

It's also the case that bid-ask spreads are very much dependent upon the market in which they are measured. The interdealer market, which trades using CLOBs, may not reflect the bid-ask spreads borne by participants in request-for-quote (RFQ) markets like the dealer-to-customer Treasury and MBS markets. In dealer-to-customer environments, which represent about half of the Treasury market and an even greater share for MBS, we have relatively poor insight into actual bid-ask spreads, because as I mentioned, observed spreads are indicative.[17] In MBS, one can use data from TRACE to construct estimates of effective bid-ask spread measures based on actual trades.

But in Treasuries it is particularly difficult to measure market liquidity in the dealer-to-customer market, because of the lack of nearly any publicly or commercially available trade data. Treasury market data collected after the Joint Staff Report suggests that the liquidity experienced in dealer-to-client markets may be different than that in highly automated markets. For example, during the most volatile period of October 15, 2014, the non-response rate to client trade inquiries rose to over 30 percent from its normal level of around 5 percent for the 10-year security (Exhibit 9). The spread between prices in the dealer-to-client and interdealer markets also widened during the volatility (Exhibit 10). More data would be necessary to understand these dynamics, suggesting that data collection and public reporting of the kind that is done in the MBS market may have value in the Treasury market as well.[18]

Bank Regulation and Risk Management

The second trend I'd like to highlight is adaptation to the post-crisis regulatory environment and ongoing risk management changes. These trends have been widely discussed by market participants, the media, and regulators, with frequent references to the shrinking amount of dealer balance sheet allocated to capital markets business lines that rely on trading inventories and repo, both of which have declined (Exhibits 11 and 12).

How do these trends relate to market liquidity? Many market participants have pointed to recent changes in fixed income relative value relationships, particularly those measuring the relative pricing of cash securities versus synthetic products, or derivatives, which receive different balance sheet treatment under current regulation. Since the middle of last year, swap spreads, or the difference between swap rates and Treasury yields, have declined and even gone negative, or dipped further into negative territory, for longer tenor rates (Exhibit 13). Over the same time frame, relative value relationships between cash Treasury securities and Treasury futures have experienced similar volatility.

A common theme among these anomalies is the influence of the rise in the cost of funding cash as compared to derivatives instruments. Market participants have pointed to constraints on dealers' repo financing of Treasuries as contributing to these trends, as such constraints increase the cost of establishing and funding positions in cash securities relative to swaps and futures. In the agency MBS market, dollar roll implied financing rates for securities currently being produced ("production coupons") have increased to multi-year highs, and in some cases exceed agency MBS term repo. Similar to the dynamics affecting the Treasury market, MBS participants cite constraints related to dealer balance sheets as driving implied financing rates above MBS repo rates.

While these developments are difficult to directly tie to overall market liquidity, changes in funding costs and funding market liquidity almost certainly will have an effect on secondary market liquidity in cash securities. Dealer balance sheets play a central role in the functioning of funding markets, which in turn are important to enable intermediation and arbitrage in financial markets more broadly.[19] Importantly, while many market participants have pointed to regulation as driving these changes, dealer balance sheet adjustments have also been influenced by private decisions to manage risk more prudently after the financial crisis.[20]

Of course, a thoughtful examination of these recent developments would weigh their costs and benefits, including the cost of potentially lower liquidity and the benefit of greater financial stability from the regulatory and risk management changes. Some increase in the price of liquidity or in market liquidity "jump" risk may be worth reducing the likelihood of the collapse of a major financial institution, which could set off sharp dislocations across markets. A cost-benefit analysis of this kind is complex, because it is unlikely that we have reached a new equilibrium: not all changes in the regulatory landscape have yet been implemented, and market participants are already adapting and finding new ways of providing liquidity. Moreover, we do not yet have robust ways of measuring some aspects of the costs, including the risk or implications associated with a potential increase in flash events or liquidity "jump" risk. It is clear that any analysis will require a deep understanding of the specific ways in which these structural changes affect liquidity and financial stability risk.

Public Sector Ownership

The third development I'd like to discuss is the evolution of public sector ownership in these markets and the possible implications for liquidity. Following the large scale asset purchase programs implemented during the global financial crisis and in the years after, the Fed's System Open Market Account (SOMA) portfolio now holds nearly $2.5 trillion of Treasuries and over $1.7 trillion of agency MBS.

Given their large size, Fed purchases or holdings have the potential to increase or decrease liquidity in these markets, and market functioning considerations have informed the implementation of purchase operations. As one example, implementation of the purchases in Treasuries took into account relative value, and our purchases provided reliable demand for less liquid off-the-run securities.[21] These factors may have helped suppress price inefficiencies in the cash market, as measured by yield curve errors. Thus some deterioration in this metric after we ceased secondary market purchases might be expected.

With respect to agency MBS, the Fed is now the largest single holder, owning roughly 30 percent of the outstanding stock. The vast majority of purchases during the purchase programs were made in newly-issued MBS traded in the TBA market, as are all of the

reinvestment related purchases we conduct today. Purchasing in the TBA market is both an efficient way to execute such sizeable transactions, and also helps avoid liquidity strains that could emerge if purchases were made in less liquid coupons.[22]

Because Fed purchases or holdings have the potential to create scarcity in the assets being purchased, in both the Treasury and agency MBS markets we employ operations designed to help support the liquidity of these markets. These include lending our Treasury holdings and conducting dollar rolls to facilitate the settlement of our agency MBS purchases.

Contemporaneous with the Fed increasing its agency MBS holdings, Fannie Mae and Freddie Mac were mandated by the FHFA to wind down their retained portfolios, a move that reduced their portfolio management and hedging activities in the market. Commercial banks, the second largest owner of MBS behind the Fed, have also reduced these activities in response new capital requirements and accounting rules, which have contributed to an increase in their allocation of holdings to passive held-to-maturity (HTM) accounts. As a result, the ownership base in the MBS market has shifted meaningfully since the crisis from those who hedge the negative convexity inherent in MBS to those that do not. How this affects liquidity is difficult to determine though there are a few hypotheses. Some analysts speculate that the narrowing of swap spreads is at least partially related to this, because active hedgers frequently use swaps as a means to hedge interest rate risk of their portfolio. Others believe this phenomenon has driven average trading volumes lower, all else equal. Lastly, the shift in the ownership base from those who hedge duration, to those who do not, likely mutes the impact of negative convexity events witnessed during times of heightened interest rate volatility, whereby hedgers need to sell in a declining market and purchase in a rising market.[23]

Looking ahead, Some Current Public Sector Initiatives

Lastly, I'd like to cast attention on some forward looking public policy initiatives at the heart of the debate around market structure and liquidity in the MBS and Treasury markets.

In Treasuries, the steps identified in the Joint Staff Report on October 15, 2014 represent the most comprehensive evaluation of the market's structure in a quarter century. As part of the follow up from that work, the Treasury Department earlier this year issued a request for information (RFI) on the evolving structure of the Treasury market, recognizing the importance of improved official sector access to data across all areas of market activity.[24] The information from the October 15 report and the RFI provide important insights for the policies that will help shape the future structure of the Treasury market. For example, a consensus has already emerged for a greater need for official sector access to transaction data, and just yesterday the Treasury and the SEC announced that they are working together to explore means of collecting cash market transaction information, working with FINRA.

In MBS, the TBA market is about to go through its greatest structural change since it was introduced nearly 50 years ago, with the Common Securitization Platform (CSP), a new infrastructure that will harmonize Fannie Mae and Freddie Mac's single-family mortgage securitization activities, and enable them to eventually issue a Single Security.[25] The Single Security TBA contract, recently dubbed Uniform MBS (UMBS), will allow either Fannie Mae or Freddie Mac securities to be delivered into a single contract.

Roughly eight years after the start of the financial crisis, continuing steps to change the structure of the mortgage market seems important, lest this market's depth and liquidity be diminished over time. For many years, Freddie Mac securities have been less liquid than their Fannie Mae peers, and market participants have suggested that there are sizeable taxpayer costs associated with maintaining separate securitization platforms for both entities.[26] Commentary on the planned Single Security has highlighted the lessons I mentioned earlier around market structure and liquidity: in order to improve liquidity, the initiative must help create a deep pool of standardized instruments, continue to attract a large and diverse group of investors, employ common securitization and trading mechanisms, and be guided by policy that is informed and led by the collaboration of the public and private sectors.

These ongoing initiatives and others build on a long history of dynamic change in the structure and liquidity of Treasury and agency MBS markets and will continue to shape their evolution in the years to come. In the process, we should be mindful to regularly reassess our interpretation and measurement of liquidity so that we understand and continue to support this critical attribute of the Treasury and agency MBS markets.

Exhibits PDF

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[1] George Eckerd and Brian Greene assisted in preparing these remarks, along with contributions from Tobias Adrian, Alain Chaboud, Michael Fleming, Frank Keane, Michael McMorrow, Brett Rose and Ernst Schaumburg, helpful comments from a number of others, and assistance with data from Romen Mookerjee and Rich Podjasek.

[2] Treasury market trading volumes can be challenging to estimate due to the lack of comprehensive data on activity across dealer-to-client and interdealer markets, see Fleming, Keane, Schaumburg (2016) Primary Dealer Participation in the Secondary U.S. Treasury Market, *Liberty Street Economics Blog,* February 9. MBS volumes are obtained from transaction data reported by members of the Financial Industry Regulatory Authority (FINRA) to the Trade Reporting and Compliance Engine (TRACE).

[3] See for example: Fleming, Mizrach, Nguyen (2009) "The Microstructure of a U.S. Treasury ECN: The BrokerTec Platform"; Grossman and Miller (1988) "Liquidity and Market Structure"; O'Hara (2015) "High Frequency Market Microstructure"; Garbade, Keane, Logan, Stokes, and Wolgemuth (2010) "The Introduction of the TMPG Fails Charge for U.S. Treasury Securities."

[4] See Garbade (2007) "The Emergence of "Regular and Predictable" as a Treasury Debt Management Strategy," *FRBNY Economic Policy Review,* for background and analysis of the evolution of Treasury auction practices.

[5] See Joint Staff Report: The U.S. Treasury Market on October 15, 2014 (JSR). Though the JSR does not specify, the contributors to the report from the Federal Reserve System included: Alain Chaboud, Dobrislav Dobrev, Michael Fleming, Frank Keane, Michael McMorrow, Suraj Prasanna, Ernst Schaumburg and Nathaniel Wuerffel, with assistance from Nashrah Ahmed, Joseph Fiorica and Ron Yang. The report was prepared in close collaboration with staff at the Department of the Treasury, the U.S. Securities and Exchange Commission, and the Commodity Futures Trading Commission.

[6] See Mizrach, Bruce and Christopher J Neely(2006) "The Transition to Electronic Communications Networks in the Secondary Treasury Market," Federal Reserve Bank of St. Louis Review for a discussion of the transition to electronic trading and its effects across markets.

[7] One study by Federal Reserve staff found that the TBA mechanism reduces borrowing costs by 9 to 12 basis points, on average, with the benefit increasing substantially during periods of stress to as many as 65 basis points; see Vickery and Wright (2013) TBA Trading and Liquidity in the Agency MBS Market, *FRBNY Economic Policy Review*. Another study estimated that the GSE guarantee reduced borrowing costs by 32-33 basis points. See Passmore (2005) "The GSE Implicit Subsidy and Value of Government Ambiguity"

[8] See the TMPG best practices page for the latest information on a wide range of market structure issues handled by the group.

[9] See Fleming (2012) Failure is No Longer a (Free) Option for Agency Debt and Mortgage-Backed Securities, *Liberty Street Economics Blog,* for further discussion of TMPG's fails charge recommendation in the mortgage market.

[10] See Margining in Agency MBS Trading, Treasury Market Practices Group, November 2012, for further information.

[11] Though definitions vary, an efficient price can generally be thought of as one that reflects the consensus valuation of an asset, incorporating all publicly available information. Research on market efficiency (see for example Abreu and Brunnermeier (2003) "Bubbles and Crashes" and Fama (1965) "The Behavior of Stock Market Prices" for perspectives on market efficiency) often explores the relative inefficiency, or mispricing, of assets within or across markets, not unlike the arbitrage opportunities that might exist along a yield curve. It would appear that in flash events, relative mispricing across instruments or markets may be little changed, and yet the market as a whole may become inefficient, no longer correctly reflecting available information. These conditions might help explain why, for example, firms employing high-speed arbitrage strategies reported that their algorithms operated within normal tolerances on October 15, 2014.

[12] For example, as noted in the JSR, short interest rate and volatility (or "gamma") positions likely amplified the moves on October 15, 2014 as market participants sought to dynamically hedge their exposures.

[13] See Schaumburg and Yang (2015) Liquidity During Flash Events, *Liberty Street Economics Blog,* August 18, for further analysis of flash events in the Treasury, foreign exchange, and equity markets.

[14] See Adrian, Fleming, Vogt (October 2015) "A Note on Measuring Liquidity Jumps" and Adrian, Stackman, Fleming, and Vogt (2015) Has Liquidity Risk in the Treasury and Equity Markets Increased?, *Liberty Street Economics Blog,* October 6, for discussion of the potential rise in liquidity risk.

[15] See Adrian, Fleming, Stackman, Vogt (2015) Has U.S. Treasury Market Liquidity Deteriorated?, *Liberty Street Economics Blog*, August 17, the first of a series of posts on Treasury market liquidity.

[16] See Podjasek, Molloy, Fleming, Fuster (2016) Has MBS Market Liquidity Deteriorated?, *Liberty Street Economics Blog*, February 8, for background on the structure and liquidity of the agency MBS market.

[17] See Fleming, Keane, Schaumburg (2016) Primary Dealer Participation in the Secondary U.S. Treasury Market, *Liberty Street Economics Blog*, February 12, for a breakdown of volumes in the Treasury market by segment.

[18] Another byproduct of increased automated trading is smaller average trade sizes in the interdealer broker and futures markets. When trading on CLOBs, participants tend to break large orders into smaller-sized trades. In the interdealer broker and futures Treasury markets, average trade size has fallen markedly over the past 10-years, coinciding with the growth of automated trading. While some associate smaller average trade sizes with lower liquidity, given these structural changes it is not clear that the interpretation is so straightforward. It is possible that small trades can be executed even more easily in highly automated markets, whereas it may be more difficult to execute large trades.

[19] See Adrian, Begalle, Copeland, Martin (2011) Repo and Securities Lending, *Federal Reserve Staff Report*, and Copeland, Davis, LeSueur, Martin (2012) Mapping and Sizing the U.S. Repo Market, *Liberty Street Economics Blog*,for a discussion of the repo market's structure and size.

[20] See Adrian, Fleming, Goldberg, Lewis, Natalucci, Wu (2013) Dealer Balance Sheet Capacity and Market Liquidity during the 2013 Selloff in Fixed-Income Markets, *Liberty Street Economics Blog,* for analysis on the drivers of dealer positioning and risk metrics.

[21] See Gagnon, Raskin, Remache, Sack (2010) "Large-Scale Asset Purchases by the Federal Reserve: Did They Work?" *FRBNY Staff Report*, which provides information on the implementation and effects of the Fed's asset purchase programs.

[22] See remarks by Simon Potter The Implementation of Current Asset Purchases, March 2013, for further details on the effects of asset purchases on the MBS market, including market functioning considerations.

[23] See Malz, Schaumberg, Shimonov, Strzodka (2014) Convexity Event Risks in a Rising Interest Rate Environment, *Liberty Street Economics Blog,* for analysis on reduced MBS hedging needs

[24] See U.S. Department of Treasury, Notice Seeking Public Comment on the Evolution of the Treasury Market Structure, January 2016, for details on the RFI.

[25] See the Common Securitization Platform by the FHFA for details on the reform.

[26] See for example The Mortgage Banker Associations response to the FHFA's request and Charting the Course to a Single Security by Lorie Goodman and Lewis Ranieri for information regarding the Single Security.