Mortgage Dollar Roll

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Abstract

Mortgage dollar roll is the most common financing strategy for agency MBS. Effectively a collateralized loan, it differs from repos in two important ways: the returned collateral can differ from those received, and the MBS ownership changes hands in the funding period. Therefore, dollar roll "specialness"—how much implied financing rates fall below MBS repo rates—is an important indicator of MBS funding conditions. Using a proprietary data set, we find that dollar roll specialness (i) increases in the value of the cheapest-to-deliver option, (ii) decreases in the leverage of primary dealers, (iii) decreases in prepayment risk exposure during the financing period, and (iv) decreases in expected MBS returns. During its QE operation, the Federal Reserve's dollar roll sales are associated with lower specialness, consistent with its objective to mitigate the (negative) impact of QE on MBS funding market.

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1 Introduction

Agency mortgage-backed-securities (MBS) guaranteed by Ginnie Mae (GNMA), Fannie Mae (FNMA), and Freddie Mac (FHLM) form a major component of U.S. fixed-income markets.[1,2] This market is important for several reasons. The first is its size. According to SIFMA, as of the second quarter of 2017, the outstanding amount of agency mortgage-backed-securities (MBS) is about $9.2 trillion, which is second only to the U.S. Treasury market with an outstanding amount of $14.0 trillion. Moreover, the agency MBS market plays a prominent role in the implementation of U.S. monetary policy since the global financial crisis. In particular, the Federal Reserve (the Fed) has conducted several rounds of quantitative easing (QE) since 2009 and accumulated $1.74 trillion face value of agency MBS on its balance sheet as of January 2015. As of October 2017, $1.77 trillion face value of agency MBS remain on the Fed's balance sheet.[3] Furthermore, the Federal Open Market Committee has announced in its September 2014 statement that the Federal Reserve will continue to involve its MBS holdings in its regular policy operations in the future (see Frost, Logan, Martin, McCabe, Natalucci, and Remache (2015)). Finally, a healthy agency MBS market is critical for the mortgage market and ultimately households. Therefore, understanding the economic forces in the agency MBS market is enormously important for policy makers, practitioners, and academics.

This paper provides an empirical analysis of the financing market, or funding liquidity, of agency MBS. A well-functioning financing market enables market participants, including

[1] Throughout the paper, the term MBS refers only to residential mortgage-backed-securities rather than those backed by commercial mortgages, unless otherwise noted.

[2] Ginnie Mae, Fannie Mae, and Freddie Mac stand for the Government National Mortgage Association, Federal National Mortgage Association, and Federal Home Loan Mortgage Corporation, respectively. Ginnie Mae is a wholly-owned government corporation within the Department of Housing and Urban Development. Usually called Government-Sponsored Enterprises (GSEs), Fannie Mae and Freddie Mac were private entities with close ties to the U.S. government before September 2008, and have been placed in conservatorship by the Federal Housing Financing Agency and supported by the U.S. Treasury department since then.

[3] See https://www.federalreserve.gov/monetarypolicy/files/quarterly_balance_sheet_developments_report_201711.pdf.

banks and broker-dealers, to utilize their balance sheets more efficiently. It also enhances price efficiency because investors can exploit mispricing more easily if the financing process faces fewer frictions. Finally, on the flip side, a shallow or frozen financing market may cause or exacerbate market stress, as exemplified in the recent financial crisis (see, for example, Gorton and Metrick (2012), He and Xiong (2012), and Krishnamurthy, Nagel, and Orlov (2014)). Therefore, a sound financing market is critical for the efficient working of the agency MBS market.

In practice, the most important method for financing agency MBS is called (mortgage) "dollar roll." A dollar roll is the combination of two forward contracts on MBS, one front month and one future month. In a dollar roll transaction, the "roll seller" sells a certain face value of MBS, promising to deliver in month t, and simultaneously buys back the same face value of MBS, to be delivered back in month $t + 1$. A dollar roll buyer does the opposite, that is, taking delivery of MBS in month t and making delivery in month $t + 1$. The prices of both legs are determined on the dollar roll trade date. The structure of dollar rolls is therefore similar to a collateralized borrowing contract, with the roll seller being the cash borrower. According to Gao, Schultz, and Song (2017), the daily trading volume of dollar rolls during the period from May 2011 to April 2013 is about $130 billion, which is just over a half of the entire MBS trading volume during the same period.[4]

While dollar rolls resemble standard repurchase agreements (repos) of agency MBS, there are two important differences, as explained below. As it turns out, a granular comparison between dollar rolls and repos along these two dimensions sheds important light on the functioning of MBS financing markets. This is our objective for the remaining of the paper.

Redelivery risk—The first difference between dollar rolls and MBS repos is redelivery risk. The dollar roll buyer, who takes deliver and pays cash in month t, need not deliver

[4]For comparison, as of 2012, the daily trading volume for U.S. Treasury securities, corporate bonds, and municipal bonds is $560, $23, and $11 billion, respectively. See SIFMA's statistics at https://www.sifma.org/resources/research/us-bond-market-trading-volume/.

back the same MBS in month $t+1$. Rather, he only needs to deliver MBS that are "substantially similar"—in terms of agency, coupon, original maturity of the mortgage, among other parameters—to those delivered by the roll seller. This flexibility or fungibility is valuable because it increases the size of the deliverable pool of MBS. In particular, the roll buyer can deliver MBS that are scheduled to be created between month t and month $t+1$. On the other hand, the roll buyer also has strong incentives to deliver the cheapest MBS CUSIPs that satisfy these parameters, creating adverse selection for the roll seller.[5] Since agency MBS are guaranteed by the agencies and involve no default risk, a cheaper MBS typically means unfavorable prepayment speeds, as we elaborate later. By contrast, this kind of redelivery risk is absent in MBS repos, where the MBS collateral are the same in the two legs of the repo trade.

Redelivery risk implies that dollar rolls tend to have lower "implied financing rates" than MBS repos. To see this, note that the settlement prices of the two legs in a dollar roll, say P_0 and P_1, can be viewed as the "principal" of a loan in month t and "principal plus interest" of repayment in month $t+1$. Because the roll buyer has the option to deliver back inferior MBS, the price of the second leg of the dollar roll, P_1, should be sufficiently lower than that of the first leg, P_0, to compensate for the roll seller's redelivery risk. Therefore, the implied financing rate in dollar rolls tends to be lower than the MBS repo rate. Specialness, measured here as MBS repo rate minus dollar roll implied financing rate, should increase in the redelivery risk in MBS markets. This is the first key economic hypothesis we test.

Ownership exchange—The second key feature of dollar rolls, relative to MBS repos, is that the roll buyer receives all interest and principal payments—hence bearing prepayment risk—during the financing period. By contrast, in MBS repos the security lender retains the

[5] The roll buyer is also subject to this adverse-selection risk between the trade date and the front-month settlement date. We expect this risk to be limited because (1) the roll buyer has the last say on the delivered CUSIP, and (2) the roll trade date is usually close to the front-month settlement date when both counterparties have a good idea on the cheapest MBS in practice. See Section 4 for detailed discussions.

cash flows during the financing period. Therefore, during the financing period, the higher is the prepayment risk exposure, the less willing is the roll buyer to hold the MBS, which implies a higher implied financing rate or lower specialness.

Closely related to the ownership of cash flows during the funding period, the accounting treatment of dollar rolls also differs from that of repos. At least during the sample period covered in our empirical analysis (July 1998 to July 2013), dollar rolls are more likely treated as sales and purchases, whereas repos are more likely treated as secured financing (see Appendix B for detailed discussions). That is, the dollar roll seller can often remove the MBS from her balance sheet during the financing period, whereas it is more difficult to do so in repos. In periods of tighter leverage constraint, we thus expect financial institutions to prefer selling MBS into dollar rolls to lending these MBS in repos, leading to a higher implied financing rate in dollar rolls and thus a lower specialness.

Empirical tests of specialness—In Section 5 we empirically test the determinants of dollar roll specialness, focusing on agency MBS whose underlying assets are pools of 30-year fix-rate mortgage loans guaranteed by Fannie Mae. Various data sets are obtained from JP Morgan, eMBS, and Bloomberg, among others. The dollar roll implied financing rates and MBS repo rates are observed from July 1998 to July 2013, from which the dollar roll specialness is constructed as the difference between the two. The coupon rates of various MBS observed range from 2% to 8.5%.

The two key features of dollar rolls, redelivery risk and ownership exchange, guide our empirical analysis. To test the effect of redelivery risk, recall that the roll buyer promises to deliver back MBS collateral that are of the same agency (in our case Fannie Mae), the same original maturity (in our case 30 years), and the same coupon rate as the MBS collateral received, but the roll buyer can choose any CUSIP(s) for redelivery that satisfy these parameters—henceforth referred to as a "cohort." The more dispersed are the values of MBS CUSIPs within this cohort, the more valuable is the roll buyer's cheapest-to-delivery option, and the higher is specialness. Since values of agency MBS are primarily affected by prepayment risk, we use the range of prepayment speeds (measured as conditional prepayment rates) across CUSIPs within the cohort to approximate redelivery risk. As expected, we find that a higher dispersion of prepayment speed is associated with a higher specialness. The economic magnitude is also large, with one standard deviation increase in the dispersion of prepayment speed associated with an increase of 41 basis points in dollar roll specialness.

If only less valuable MBS are delivered into dollar roll contracts, how do investors trade more valuable MBS? The answer is the specified-pool market, in which each MBS CUSIP is traded separately at its own price (see Gao, Schultz, and Song (2017)). Investors who wish to trade more valuable MBS CUSIPs would prefer specified-pool market to avoid adverse selection associated with the cheapest-to-delivery option in dollar rolls. Hence, investors' concerns over redelivery risk in dollar rolls could be measured by the difference between the volume-weighted average price of specified-pool market and the dollar roll price, for a given delivery date. As expected, we also find that specialness is increasing in this price difference.

To test the effect of ownership exchange, we construct two measures. The first reflects the fact that the roll buyer receives principal and interest payments during the financing period and hence bears the prepayment risk. This risk is approximated by the ex post changes in the conditional prepayment rate for the cohort. The second measure is the leverage of primary dealers, following He, Kelly, and Manela (2017). As discussed above, we expect dollar roll specialness to be lower when primary dealers have higher leverage. These two predictions from ownership exchange are also confirmed in the data. A one standard deviation increase in the measures of prepayment risk transfer and leverage ratio is associated with a decrease of 21 and 11 basis points in dollar roll specialness, respectively.

Finally, we expect dollar roll specialness and MBS returns to be negatively correlated. Indeed, a high specialness of dollar rolls essentially means a relatively high price P_0 in the first leg, compared to the price P_1 in the second leg. In equilibrium, the "side benefit" of holding agency MBS during the financing period—low implied financing rates—should be (partly) offset by a lower expected return of MBS. As expected, specialness and expected MBS returns are strongly negatively correlated in the data. One percentage point increase of specialness is associated with 20-46 basis points decrease in rolling-TBA-strategy returns,

Federal Reserve's dollar roll sales as a policy tool—An important component of the Federal Reserve's unconventional monetary policy during the financial crisis is the large outright purchase of agency MBS. While such purchases keep a downward pressure on long-term interest rates, they also cause concerns about the potentially negative impact on market functioning, such as a supply shortage of agency MBS. To mitigate such negative impact, the Federal Reserve has conducted dollar roll sales, effectively delaying taking delivery of agency MBS. In certain coupon cohorts, the Fed's dollar roll sales are over 60% of the outright purchase amount. In its public communication, the Fed explicitly states that it monitors dollar roll specialness as indications of supply shortage (or abundance) and determine whether to trade dollar rolls accordingly.

In Section 7, we examine how the Fed's dollar roll sales affect dollar roll specialness. As we discuss in more detail in Section 7, the effect of MBS supply is in fact not obvious a priori because supply affects both MBS repos and dollar rolls. Moreover, the intended effect of dollar roll sales by the Fed is potentially confounded by other economic forces, including redelivery risk and ownership exchange. Despite the theoretical ambiguity, the effect of the Fed's dollar roll sales remains a worthwhile empirical question given the Fed's explicit use of it as a policy tool. Indeed, we find that after the Fed sells dollar rolls in certain coupon cohorts, the specialness in the affected coupon cohorts decreases significantly, in the order of about 50 bps, relative to coupon cohorts in which the Fed does not sell dollar rolls, after controlling for other covariates. This evidence suggests that the Fed's dollar roll sales effectively mitigate the supply shortage of agency MBS during its QE operations.

1.1 Relation to the literature

To the best our knowledge, this paper is the first academic study of dollar rolls as the most important funding strategy for agency MBS. It contributes to a few strands of literature: MBS markets, repo specialness, Federal Reserve's asset purchases, and the asset pricing implications of financial intermediaries' funding constraints.

The early literature on MBS markets has predominantly focused on prepayment models for MBS valuation, including Dunn and McConnell (1981), Schwartz and Torous (1989), Stanton (1995), Boudoukh, Richardson, Stanton, and Whitelaw (1997), and Kupiec and Kah (1999), among others. Several recent studies, such as Gabaix, Krishnamurthy, and Vigneron (2007), Duarte, Longstaff, and Yu (2007), Chernov, Dunn, and Longstaff (2018), Boyarchenko, Fuster, and Lucca (2015), Diep, Eisfeldt, and Richardson (2017), and Carlin, Longstaff, and Matoba (2014), investigate the return dynamics of MBS. More recently, Malkhozov, Mueller, Vedolin, and Venter (2016) and Hansen (2014) show that variables that capture the hedging motives of mortgage risks have return predictive power for Treasury bonds. An expanding literature studies the market structure and liquidity of the agency MBS, including Atanasov and Merrick (2012), Bessembinder, Maxwell, and Venkataraman (2013), Downing, Jaffee, and Wallace (2009), Friewald, Jankowitsch, and Subrahmanyam (2017), Gao, Schultz, and Song (2017, 2018), Schultz and Song (2018), and Hollifield, Neklyudov, and Spatt (2017). Our analysis differs from this group of papers because we focus on the funding market of agency MBS.[6]

Our study is also related to the literature on special repo rates in Treasury markets, including Duffie (1996), Jordan and Jordan (1997), Buraschi and Menini (2002), Krishnamurthy (2002), Duffie, Garleanu, and Pedersen (2002), Cherian, Jacquier, and Jarrow (2004), Vayanos and Weill (2008), Pasquariello and Vega (2009), and Banerjee and Grave-

[6]After our paper has been widely distributed in January 2014, a very recent paper Kitsul and Ochoa (2014) conducted some similar analyses.

line (2013), among others. The economics of dollar roll specialness in agency MBS markets differs substantially from that of Treasury repo specialness. The Treasury repo specialness is the difference between the rate of a specific collateral repo, which accepts only one specific Treasury security as collateral, and the rate of a general collateral repo, which accepts any Treasury security as collateral. As shown by these studies, the Treasury repo specialness reflects the demand for individual specific CUSIPs that can arise from primary issuance, liquidity coordination, or short interest, among other reasons. In contrast, dollar roll specialness reflects the funding condition for an MBS cohort rather than individual MBS. We show that redelivery risk and ownership exchange are two key economic channels that distinguish dollar roll from repo. Relatedly, Bartolini, Hilton, Sundaresan, and Tonetti (2011) and Smith (2013) study the variation in the spread of Treasury vs MBS GC repo rates, whereas our paper studies the spread between MBS GC repo rates and dollar roll financing rates. Together, a complete picture is obtained regarding the economic forces that drive the funding conditions of agency MBS against those of Treasuries as the benchmark.

The effect of QE on the *level* of mortgage rates, MBS yields, and financing rates are studied by Hancock and Passmore (2011), Gagnon, Raskin, Remanche, and Sack (2011), Kandrac (2013), Krishnamurthy and Vissing-Jorgensen (2011), Krishnamurthy and Vissing-Jorgensen (2013), and Stroebel and Taylor (2012), among others. Chakraborty, Goldstein, and MacKinlay (2017) studies how QE affects banking lending. Complementary to these studies, we investigate how the Federal Reserve used dollar roll to mitigate potential adverse effects of QE on MBS funding conditions.

Finally, our finding on the negative relation between primary dealers' leverage ratio and dollar roll specialness adds further evidence to the expanding literature on how constraints of financial intermediaries affect asset pricing. Relevant papers in this literature include Adrian, Etula, and Muir (2014), He, Kelly, and Manela (2017), Haddad and Muir (2017), Du, Tepper, and Verdelhan (2017), Chen, Joslin, and Ni (2016)), and Fleckenstein and

Longstaff (2017), among others. He and Krishnamurthy (2017) survey both theoretical and empirical studies of intermediary-based asset pricing.

2 Institutional Details of TBA Market and Dollar Roll

This section discusses institutional details of the TBA trading convention in agency MBS markets and dollar roll transactions, which consist of two simultaneous TBA trades (see Hayre (2001) and Hayre and Young (2004) for detailed industry references of MBS markets).[7]

2.1 TBA market

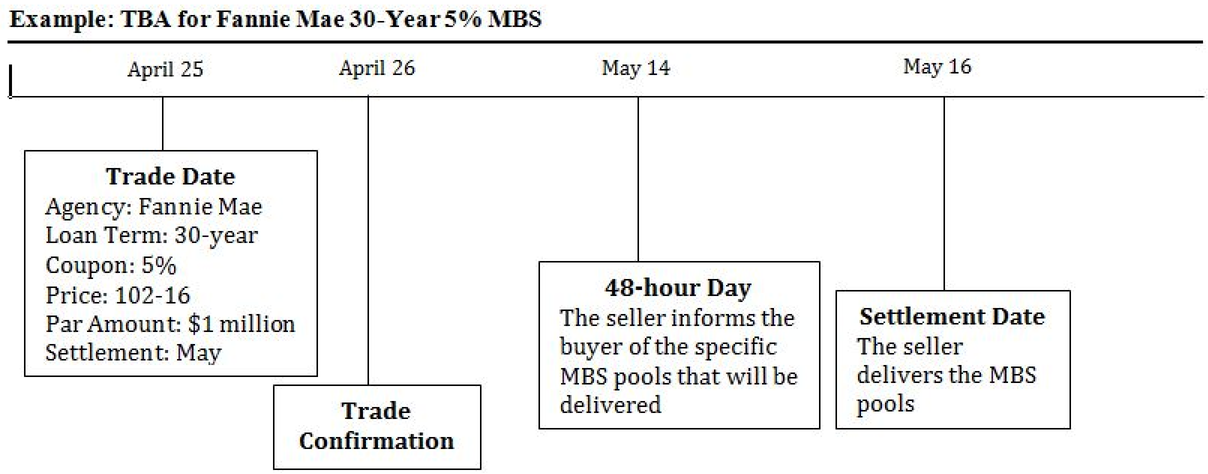
A TBA contract is essentially a forward contract to buy or sell an MBS. In a TBA trade, the buyer and seller negotiate on six general parameters: agency, maturity, coupon rate, par amount, price, and settlement date. Different from other forward contracts, there is only one settlement date per month for TBA contracts, set by SIFMA. For example, for 30-year FNMA MBS, the settlement day is usually the 12th or 13th of the month. A single settlement date per month concentrates liquidity.

We now demonstrate the trading procedure in TBA markets through a concrete and hypothetical example, illustrated in Figure 1, following Hayre (2001).

- Trade and Confirmation Dates. On the trade date April 25, the buyer and seller decide on the six trade parameters. In this example, a TBA contract is initiated on April 25 and will be settled on May 16. The seller can deliver any MBS issued by Fannie Mae with the original mortgage loan term of 30 years, annual coupon rate of 5%, par amount of \$1 million, and price at \$(102+16/32) per \$100 of par amount. The trade is confirmed within one business day, which in this case is April 26.

[7] All TBA-eligible MBS are so-called "pass-through" securities, which pass through the monthly principal and interest payments less a service fee from a pool of mortgage loans to owners of the MBS. Structured mortgage-backed-securities like CMOs, which tranche mortgage cash flows with various prepayment and maturity profiles, are not eligible for delivery in TBA contracts.

Figure 1: A TBA Example



Notes: This TBA trade is hypothetical.

- 48-Hour Day. The seller notifies the buyer the actual identity (i.e., the CUSIPs) of the MBS to be delivered on the settlement date, no later than 3 p.m. two business days prior to the settlement date ("48-hour day"), which is May 14 in the example. These MBS pools have to satisfy the "Good Delivery" requirements set by SIFMA. For example, for each $1 million lot, the contract allows a maximum of three pools to be delivered and a maximum 0.01% difference in the face value; that is, the sum of the par amounts of the pools can deviate from $1 million by no more than $100 in either direction.

- Settlement Date. The seller delivers the MBS pools specified on the 48-hour day, and the buyer pays an amount of cash equal to the current face value times the TBA price (i.e., 102-16 in this example) plus accrued interests from the beginning of the month, given that the seller holds the MBS pools until the settlement date. Accrued interest is computed on a 30/360 basis. There is one settlement date for a type of TBA contract in each month, fixed by SIFMA. For example, FNMA and FHLM 30-year TBA trades settle on the same Class A schedule that typically falls around the 12th or 13th of each month (Gao, Schultz, and Song (2017)).

The unique feature of a TBA trade is that the actual identity of the MBS to be delivered at settlement date is not specified on the TBA trade date. By specifying only a few key MBS characteristics, this TBA trading design dramatically increases the set of deliverable MBS and substantially improves market liquidity. Another reason for the prevalence of TBA trading is that it helps mortgage originators to hedge interest rate exposure on a future loan after a borrower locks in a rate but before the loan is closed. In particular, mortgage borrowers can usually lock in a mortgage rate for 30 - 90 days before the loan is finalized, so lenders are exposed to the fluctuation or risk of interest rate between the lock-in date and the loan closing date. TBA contracts allow the originators to sell forward mortgage loans that are still in the pipeline of originating, hence hedge against this risk. Almost all newly issued agency MBS trade as TBAs (Hayre (2001)).

2.2 Dollar rolls

A dollar roll transaction consists of two TBA trades. The "roll seller" sells an MBS in the front month TBA contract and simultaneously buys an MBS in the future month TBA contract with the *same TBA characteristics*, at specified prices. In particular, the two MBS delivered into the two TBA contracts need not have the same CUSIP, as long as they have the same TBA characteristics. Hence, dollar rolls bring great flexibility to market participants in adjusting their MBS positions. In particular, investors use dollar rolls as collateralized loans, with great flexibility in the underlying MBS collateral, for a period between the front month and future month. Investors can also delay the scheduled delivery of MBS in a month to a future month by conducting a dollar roll sale should some operational issues arise (Vickery and Wright (2011)).

Figure 2 shows the time line of an example dollar roll trade. In this example, the roll seller sells an MBS for May 16 settlement and buys it back for June 16 settlement, for a par amount of \$1 million Fannie Mae MBS with the original loan term of 30 years and annual coupon rate of 5%, and with the front and future month prices at 102-16 and 102-2 per \$100 of par amount, respectively.

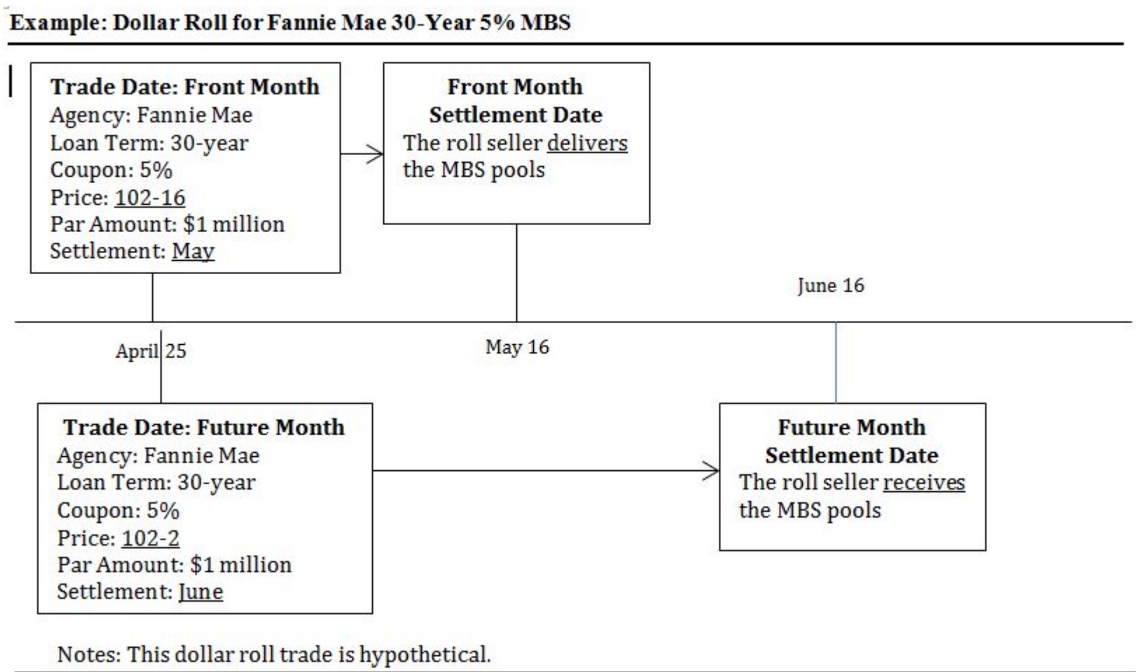
The "drop" of this dollar roll, defined as the price difference between the front- and future-month TBA contracts, is positive for two reasons. (In this example, the drop is $100\frac{16}{32} - 100\frac{2}{32} = \frac{14}{32}$ per \$100 par value.) First, the returned MBS pool in the future-month TBA contract may have inferior prepayment behavior and hence lower value than the original MBS sold in the front-month contract. Second, after the front-month leg of the dollar roll transaction, the roll seller gives up the ownership of the MBS and any interest and principal payments. These two key features differentiate the dollar roll from an MBS repo transaction. In an MBS repo trade the same MBS pool has to be returned, and the original owner collects principal and interest payments during the term of repo.[8]

2.3 Implied financing rate and dollar roll specialness

A dollar roll can be viewed as a collateralized borrowing contract, with the important feature that the returned collateral can differ from the original collateral. As in repo contracts, we can calculate the effective collateralized borrowing rate for dollar roll transactions. The borrowing rate of a dollar roll, which measures the benefit of rolling an MBS pool relative to holding it, can be computed based on the drop after adjusting for the principal and coupon payments the roll seller gives up over the roll period. As an over-simplified example, suppose that the front-month and future-month prices of the dollar roll transactions are P_0 and P_1, respectively, and the coupon and principal payments of the MBS received by the roll buyer

[8]Additionally, the cash lender in a repo transaction is generally able to call margin from the cash borrower periodically (as often as daily), protecting the lender against counterparty risk associated with fluctuations in the underlying collateral value.

Figure 2: A Dollar Roll Example



are c and d, respectively. Then, the effective financing rate of the dollar roll is

$$r = \frac{P_1 + c + d}{P_0} - 1. \tag{1}$$

A worked example of calculating the implied dollar roll financing rate is provided in Appendix A.

We say a dollar roll is "on special" if the implied finance rate is lower than the prevailing interest rates, such as MBS repo rates. The specialness of a dollar roll, defined as the general collateral MBS repo rate less the implied finance rate in a dollar roll, provides a rent to the MBS owners and represents an effective reduction in the financing costs of MBS positions. A positive specialness, however, is not an arbitrage in any sense, because the returned collateral may differ from those delivered. Detailed economic hypotheses of dollar roll specialness are discussed in Section 3.

2.4 Participants in dollar roll market

Participants in the TBA and dollar roll markets include MBS dealers, mortgage servicers, pension funds, mutual funds, endowments, hedge funds, commercial banks, and insurance companies. The Federal Reserve and foreign central banks with large dollar reserves (e.g. China and Japan) sometimes participate in MBS markets as well. Among them, commercial banks, insurance companies, and pension funds mostly use buy-and-hold strategies and only trade dollar rolls occasionally, due to accounting considerations. Much of the dollar roll demand comes from MBS dealers who need to cover their short MBS hedging trades or maintain their MBS inventories for market-making.[9] Mortgage servicers and money managers are main sellers of dollar rolls, with the former financing their MBS positions to hedge their interest rate exposure of the loans they service on their books and the latter enhancing their portfolios returns at desirable financing rates. Hedge funds demand or supply dollar rolls for both hedging and speculation.

3 The Economics of Dollar Rolls: Hypotheses

In this section we discuss the economics of dollar roll specialness in a series of hypotheses, which are subsequently tested in the empirical sections. We focus on how the unique features of dollar roll contracts affect dollar roll specialness. At the end of the section we briefly discuss the relation between dollar roll specialness and expected MBS returns.

Redelivery Risk. As we discussed in the introduction and the previous section, the first key feature of financing MBS by dollar roll, relative to financing by repo, is that the roll buyer (who lends cash and receives MBS collateral) has the option to deliver different MBS collateral at the end of the funding period, as long as the collateral satisfy the "substantially

[9]Dealers' short positions in MBS could be hedges against their long positions in CMOs, specified pools, certain non-agency MBS, or bonds they have purchased for delivery in future months from originators.

similar" criterion set by SIFMA. As a compensation, the roll seller offers a low buy-back price that implies a low effective financing rate, or a high specialness. Intuitively, this redelivery risk should depend on the value dispersion of MBS eligible for delivery: the higher is the dispersion, the lower is the expected value of the returned MBS collateral. Here, the value of the MBS can be measured by the price of the MBS per unit principal, which crucially depends on the prepayment speed as the default risk is absent. Therefore, we have the following hypothesis.

Hypothesis 1 *Dollar roll specialness positively depends on the dispersion of prepayment speeds within the basket of MBS eligible for delivery.*

The quality dispersion underlying Hypothesis 1 could have an upper bound. As the quality dispersion of deliverable MBS basket becomes larger, the roll seller expects to be delivered back a worse MBS and would be unwilling to deliver a high-quality MBS to begin with. For this reason, we expect higher-quality MBS to be traded in the specified pool market, in which the same collateral must be delivered in both legs of the trade. (See Gao, Schultz, and Song (2017) for more discussion of the specified pool market.) Therefore, specified pool trading should become more active as the qualities of various deliverable MBS for TBA and dollar rolls become more dispersed. This mechanism is stated in the following hypothesis.

Hypothesis 2 *Dollar roll specialness is positively related to the trading volume of corresponding specified pools.*

Ownership Exchange. The second key feature of financing MBS by dollar roll is that the security ownership changes hands over the funding period. That is, the security borrower owns the MBS collateral and collects the principal and interest payments during the funding period in dollar rolls, whereas the security lender keeps the ownership of the MBS collateral in repos. This feature of ownership exchange generates two economic effects on dollar roll specialness.

First, financing MBS by dollar roll is more likely to be off-balance-sheet (treated as purchase and sales in accounting), whereas financing by repo is more likely to be on-balance-sheet (treated as security financing in accounting). We say "more likely" because the accounting treatment of dollar rolls and repos can be ambiguous, depending on, among other factors, whether the collateral lender maintains "effective control" of the collateral. Appendix B further investigates the practical interpretation of relevant accounting standards and finds that dollar rolls are treated as off-balance-sheet financing by important players such as Federal Reserve Banks and GSEs.

Since the size of the balance sheet (total asset) is a key variable for determining leverage, dollar roll financing reduces leverage relative to repo financing. Therefore, when financial institutions face leverage constraints, we would expect them to prefer dollar rolls to repos in financing their MBS positions. In consequence, highly levered financial institutions would be willing to sell MBS collateral now for a relatively lower price and offer to buy them back later at a relatively high price, implying a higher dollar roll financing rate relative to the repo rate, or lower dollar roll specialness. This effect is summarized in the following hypothesis.

Hypothesis 3 *Dollar roll specialness is negatively associated with the leverage of financial institutions.*

The second effect of ownership exchange in dollar rolls is a transfer of prepayment exposure. During this period, the roll buyer, rather than the roll seller, receives all principal and interest payments, hence bearing the prepayment exposure. Because prepayment implies a loss to holders of premium MBS but a profit to holders of discount MBS, the roll buyer is expected to demand a higher (lower) financing rate for receiving a premium (discount) MBS collateral if the expected prepayment speed is higher. This effect of prepayment exposure transfer on dollar roll can be summarized by the following hypothesis.

Hypothesis 4 *Dollar roll specialness depends positively (negatively) on the prepayment speed of premium (discount) MBS collateral over the financing period.*

Dollar Roll Specialness and MBS Returns. Finally, we study how dollar roll financing is related to MBS cash trading. As illustrated in Duffie (1996), Duffie, Garleanu, and Pedersen (2002), and Chatterjee and Jarrow (1998), among many others, there exists a generic relation between security financing and cash trading, in which a low financing rate of a security gives its holders a "convenience yield" in the financing market, increasing its price; consequently, these holders are willing to accept a lower expected return in the cash market. Therefore, we expect a negative relation between dollar roll specialness and MBS returns.

Hypothesis 5 *Expected MBS returns are negatively associated with dollar roll specialness.*

4 Data

Our empirical analysis employs several data sets.

4.1 Dollar roll financing rate and specialness

The first data set comprises daily observations of dollar roll implied financing rates (IFRs) for FNMA 30-year dollar roll contracts of the next two delivery months. Hence, the funding period is one month between the two settlement dates. The data series are furnished by J.P. Morgan, based on expected prepayment rate from their proprietary prepayment model that is re-calibrated to historical data every month.[10] To compute the dollar roll specialness, we

[10] As discussed later, we conduct several robustness checks to make sure that our results do not hinge on J.P. Morgan's prepayment model.

subtract the dollar roll financing rates from the 1-month general collateral (GC) repo rate of agency MBS, provided by ICAP through Bloomberg.[11]

The IFRs and GC repo rates are available at the daily frequency from July 1998 to July 2013, but we construct monthly series to align with other variables that are only available at the monthly frequency, such as MBS prepayment rates. Specifically, we use the observation on the day before the notice day for delivery in each month. This choice facilitates the analysis and interpretation in several aspects.[12] First, on the day before the notice day, there is little uncertainty regarding the value of the MBS collateral that will be delivered because investors (both sellers and buyers of the dollar roll) have a good idea about which CUSIPs constitute the cheapest-to-deliver basket several days before the settlement date. Therefore, the redelivery risk in the dollar roll contract is mostly borne by the roll seller. Second, a dollar roll on the day before the notice day is the most comparable to a 1-month repo, with only a two-day mismatch, which reduces measurement errors in the calculation of specialness. Third, dollar roll financing rates on the day before the notice day are probably less noisy than on other days because it is one of the several days with the highest daily dollar roll trading volume (see Gao, Schultz, and Song (2017)).

Furthermore, dollar roll contracts are traded for generic cohorts with pass-through rates in increments of 50 basis points. To ensure that we use actively traded cohorts, we limit the sample to dollar rolls with moneyness (defined as the difference between the generic pass-through rate and the current-coupon rate for a synthetic par TBA contract that is obtained by interpolation of TBA prices trading near par) in the range $(-1.75\%, 3.75\%)$.[13] Our choice

[11] We also use the GCF repo rates of agency MBS, which are available from May 2005, and obtain similar results.

[12] We also conducted our main empirical analysis using alternative constructions of monthly series, such as averages from seven to one trading days before the notice day (both inclusive) each month. The results are similar.

[13] Table IA.2 of the internet appendix reports the main results on the determinants of dollar roll specialness with an aggressive sample reduction: we exclude the 2% cohort and restrict the moneyness range to $(-0.75\%, 2.75\%)$. This further restriction is imposed to focus only on cohorts that are very actively traded, hence resulting in a even smaller and more conservative sample. The results remain significant and robust.

of moneyness is comparable to that used in other recent studies of MBS. For example, Diep, Eisfeldt, and Richardson (2017) focus on MBS with moneyness in the interval $[-2.0\%, 3.5\%]$, and Boyarchenko, Fuster, and Lucca (2015) focus on the moneyness interval $[-2\%, 4\%]$. We further exclude cohorts that either have no outstanding balance based on the eMBS data of agency MBS outstanding balance and cohorts that are not traded based on the the TRACE data of agency MBS transactions.

Overall, our main data set of dollar roll financing rates and specialness is an unbalanced panel, with the general sample period from July 1998 to July 2013 but varying coverage for different cohorts. Panels A and B of Table 1 respectively present summary statistics of the sample period and moneyness of the various cohorts included.[14] We observe that the generic pass-through rates range from 2% to 8.5%. Given the downward trend of mortgage rates in the sample period (as shown in Figure 3), higher (lower) coupon cohorts appear in the early (late) part of the sample. The time series mean of moneyness increases with pass-through rate from -0.73% to 2.43% , with the highest and lowest values being 3.74% and -1.72%, respectively.

Panels C and D of Table 1 provide summary statistics of the dollar roll implied financing rates and specialness. The time series mean of IFR increases with the cohort pass-through rate, taking negative values for cohorts up to 4%. For all cohorts, the lowest IFR is negative, reaching as low as -4.81% for the 2.5% coupon cohort. The time series mean of specialness roughly decreases from 1.87% to -0.96% with the cohort pass-through rate. The highest value of specialness of all cohorts is 5.13% for the 2.5% cohort. Furthermore, Figure 4 presents the monthly time series of dollar roll specialness for the cohort with moneyness in the interval $(-0.25\%, 0.25\%]$, which is the cohort with the pass-through rate being the

[14]It is worth noting that most of our main results only use a much smaller sample than those summarized in Table 1 due to the limited availability of certain explanatory variables such as the measures of redelivery risk and prepayment exposure transfer. Therefore, many cohorts that have low outstanding balance or trading activity are already excluded for these results, e.g., those in Table 6.

Table 1: Summary of the Sample, Moneyness, Implied Financing Rate, and Specialness of Dollar Rolls

Coupon	A: Sample			B: Moneyness (%)				C: IFR (%)				D: Specialness (%)			
Rate (%)	Begin	End	N	mean	sd	min	max	mean	sd	min	max	mean	sd	min	max
2.0	2013/01	2013/07	7	-0.73	0.44	-1.58	-0.33	-1.65	0.21	-1.97	-1.42	1.87	0.22	1.59	2.15
2.5	2011/10	2013/07	22	-0.20	0.39	-1.08	0.42	-0.84	1.06	-4.81	0.15	1.10	1.08	-0.01	5.13
3.0	2010/08	2013/07	34	-0.10	0.67	-1.42	0.92	-0.76	0.87	-3.31	0.22	1.01	0.85	0.03	3.48
3.5	2009/01	2013/07	53	-0.02	0.80	-1.52	1.42	-0.60	0.77	-3.48	0.73	0.86	0.77	-0.23	3.78
4.0	2008/12	2013/07	54	0.46	0.81	-1.02	1.92	-0.06	0.31	-0.79	0.57	0.33	0.30	-0.26	1.06
4.5	2003/05	2013/07	116	-0.09	1.16	-1.69	2.42	1.40	2.13	-2.38	5.74	0.37	0.65	-2.04	3.60
5.0	2002/08	2013/07	128	0.32	1.15	-1.38	2.92	1.29	2.24	-2.57	5.54	0.54	0.74	-1.78	2.88
5.5	1998/12	2013/07	154	0.51	1.26	-1.67	3.42	1.78	2.27	-2.06	6.13	0.37	0.70	-1.87	2.45
6.0	1998/07	2013/07	166	0.77	1.31	-1.72	3.67	2.26	2.33	-1.59	6.58	0.25	0.62	-2.00	1.89
6.5	1998/07	2013/07	162	1.01	1.25	-1.61	3.74	2.63	2.43	-2.37	7.47	0.14	0.93	-7.21	2.65
7.0	1998/07	2013/07	154	1.34	1.14	-1.44	3.72	2.88	2.43	-3.88	6.63	0.06	0.99	-5.11	4.05
7.5	1998/07	2011/07	147	1.74	1.06	-0.94	3.73	3.76	2.24	-1.31	7.30	-0.69	1.62	-6.03	2.52
8.0	1998/07	2011/04	137	2.11	0.98	-0.44	3.74	3.94	2.21	-0.47	7.03	-0.66	1.77	-6.57	2.25
8.5	1998/07	2009/06	122	2.43	0.87	0.06	3.74	4.60	1.61	0.90	7.41	-0.96	1.60	-6.69	2.24

Note: Panel A reports the beginning month, ending month, and the number of monthly observations for the sample of dollar roll contracts included throughout the paper. Panels B, C, and D report basic summary statistics, including mean, standard deviation (sd), minimum, and maximum, for the monthly series of moneyness, implied financing rate (IFR), and specialness, all in percentage points. The sample covers dollar rolls across generic TBA cohorts ranging from 2% to 8.5%, but has moneyness restricted to (-1.75%, 3.75%). The overall sample period is from July 1998 to July 2013.

Figure 3: **Primary Mortgage Rate and Current-Coupon Rate**

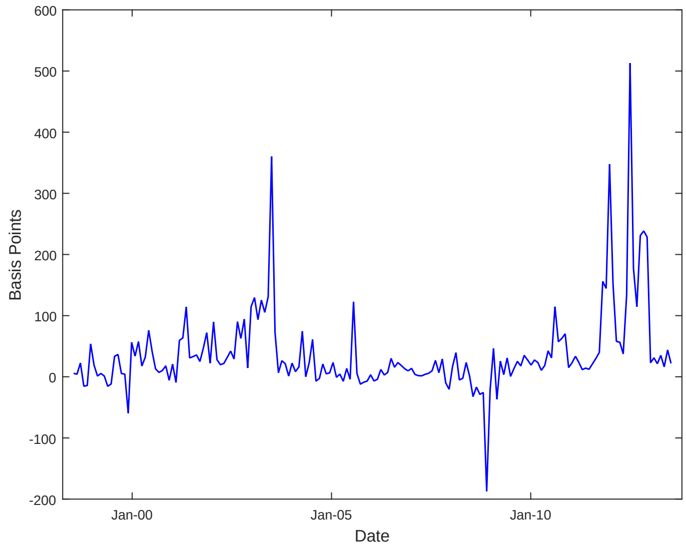
Note: This figure plots monthly time series of primary mortgage rates (PMMS) for 30-year fixed-rate mortgage loans, from the Freddie Mac primary mortgage market survey, as well as the current-coupon rate or par coupon rate of a synthetic par TBA contract obtained by interpolating TBA prices trading near par. The sample period is July 1998–July 2013.

closest to the prevailing mortgage rate. We observe large variations in dollar roll specialness over time, which reflects time-varying funding conditions in the agency MBS market.

4.2 MBS prepayment rates and characteristics

We use two sets of prepayment data. The first contains the median prepayment forecasts collected by Bloomberg through monthly surveys of important MBS dealers starting from 1993. Also used by Diep, Eisfeldt, and Richardson (2017) and Carlin, Longstaff, and Matoba (2014), these forecasts are for generic TBA cohorts under a few interest rate scenarios. They are available at the daily frequency as dealers can update their prepayment projections on a daily basis at their discretion. Similar to Diep, Eisfeldt, and Richardson (2017), we use the forecasts for the base rate scenario that assumes rates to remain unchanged. The prepayment forecasts are quoted according to the Public Securities Association (PSA) convention, which

Figure 4: Dollar Roll Specialness of the Closest-to-Par Cohort



Note: This figure plots monthly time series of the specialness for the closest-to-par cohort of FNMA 30-year MBS, from July 1998 to July 2013. The closet-to-par cohort in month t is the cohort that has moneyness (the difference between the cohort coupon rate and par/current coupon rate) in the range $(-0.25, 0.25]$ in that month.

we convert into annualized conditional prepayment rate (CPR) using standard conversion formulas (see BMA (1999)). In addition, these forecasts are available on the 15th of a month, which are only a few days after the TBA settlement day of each month. We use the prepayment forecasts from July 1998 to July 2013 to match the data sample of dollar roll specialness.

The second set of prepayment data contains CUSIP-level realized prepayment rates of all available TBA-eligible FNMA 30-year MBS, at the monthly frequency, obtained from eMBS. For each MBS CUSIP, this data set reports the realized single monthly mortality rate (SMM), which is equal to the fraction of the scheduled balance (= total beginning balance − scheduled principal payment) at the beginning of the month that was prepaid during that month. We convert the SMM into the annualized CPR by $CPR = 1 - (1 - SMM)^{12}$. Similar to the prepayment forecasts, we use realized prepayment rates (that became available starting from 1990s) over the period from July 1998 to July 2013 to match the data sample of dollar roll specialness.

In addition to the realized prepayment rates, at the CUSIP level, we also obtain MBS characteristics such as the weighted average original FICO score, weighted average original loan-to-value ratio (LTV), remaining principal balance, percentage of the refinance loans, weighted average coupon rate (WAC), weighted average maturity (WAM), production year, and issuance amount, which are important variables in prepayment models (Fabozzi and Mann (2011)). These MBS characteristics are available at the monthly frequency, but the disclosure of many of these variables, such as the FICO score, LTV, and percentage of the refinance loans, only started in 2003 by Fannie Mae (see Hayre (2001)). We obtain these series from eMBS for the period from July 2005 to July 2013. We will later use these characteristics to narrow the universe of all MBS to the universe of TBA deliverables. Hence, when we use CUSIP-level prepayment rates introduced above, we restrict the time period to July 2005 and later, even though some data are available before 2005 (see Section 5.1 for details).

4.3 MBS transactions

Parallel to TBA are specified pool trading. The key difference is that specified pool trading "specifies" which CUSIP the short side must deliver, hence eliminating the cheapest-to-deliver option. As a comparison, we obtain the transactions data of TBA and specified pools, made available by FINRA through its Trade Reporting and Compliance Engine (TRACE) since May 2011. Each trade record contains the loan term, coupon rate, agency, price, par value, trade date, and settlement month, among others. The data include both inter-dealer trades and trades between dealers and customers.

We obtain all MBS transactions from May 2011 to July 2013, although we only keep the trades of FNMA 30-year MBS given its high liquidity. Moreover, for outright TBA and dollar roll trades, we only keep those with the next two settlement months. For specified pool trades, we only keep those with TBA-eligible MBS as underlying securities.

4.4 MBS yields and returns

To measure expected MBS returns, we use two empirical proxies: the option-adjusted spread (OAS) and the return of trading strategy that rolls TBA every month. As used by Gabaix, Krishnamurthy, and Vigneron (2007) and Boyarchenko, Fuster, and Lucca (2015), among others, the OAS is the interest rate spread added to the term structure of interest rates such that the present value of the expected future cash flows of an MBS, after adjusting for the value of homeowners' prepayment options, equals the market price of the security. Intuitively, the OAS measures the expected return an investor earns, relative to certain benchmark interest rates, by buying an MBS and hedging out the expected prepayments. We use OAS based on the LIBOR swap yield curve that are quoted uniformly and densely in practice (see Fabozzi and Mann (2011), Belikoff, Levin, Stein, and Tian (2010), and Boyarchenko, Fuster, and Lucca (2015)).[15]

One potential issue with OAS is that its calculation depends on a particular prepayment model. To address this issue, following the method of Carlin, Longstaff, and Matoba (2014), we also use the return of a strategy going long one-month TBA, investing the TBA price in a riskless margin account, and then rolling the portfolio over every month on the monthly TBA settlement date. This rolling-TBA return does not depend on any model or assumption about mortgage prepayment rates or interest rate paths.

We obtain daily OAS series from July 1998 to July 2013 and daily rolling-TBA return series from February 2000 to July 2013 from J.P. Morgan, for various generic FNMA 30-year TBA cohorts. Similar to the construction of monthly series of dollar roll financing rates in Section 4.1, we use the values of OAS and rolling-TBA return on the day before the notice

[15] Using option-adjusted spread against the Treasury yield curve has similar results.

day for each month as the respective monthly observations. We also restrict the sample to cohorts with moneyness within the range $(-1.75\%, 3.75\%)$, as is done for the sample of dollar roll financing rates. Table 2 provides summary statistics of the monthly OAS and rolling-TBA return series. We observe that the time-series mean of OAS ranges from about 6 to 60 basis points. It is higher for cohorts with high and low pass-through rates than for intermediate cohorts. The time-series mean of rolling-TBA return mostly increases with the pass-through rate across cohorts.

4.5 Constraints of financial institutions

To measure the leverage constraints of financial institutions that are important in MBS markets, we use the $\frac{\text{asset}}{\text{equity}}$ leverage ratio of publicly traded bank holding companies of primary dealers,[16] following He, Kelly, and Manela (2017). The bank holding companies include both the security dealer subsidiaries and non-dealer subsidiaries, in particular those that conduct mortgage lending activities and provide mortgage serving.[17] Both subsidiaries participate in TBA markets actively, hence the leverage ratio at the bank holding company level suites our analysis well. Moreover, not only are primary dealers among the most important financial institutions in MBS markets and the most active investors in MBS repos and dollar rolls, they are also direct counterparties of the Federal Reserve in its purchases of agency MBS in the quantitative easing programs (see Section 7 for details). The data are available on the web page of Asaf Manela. We use the daily time series of this leverage measure, available from January 2000, and construct monthly series using the values on the day before the notice day for each month, similar to the construction of monthly series of dollar roll financing rates in Section 4.1.

[16]It is the sum of market equity and book debt divided by market equity at the bank holding company level.

[17]Another important leverage measure in the literature is proposed by Adrian, Etula, and Muir (2014), which focuses on security dealers (not the holding companies) based on the Federal Reserve Flow of Funds table and is available at the quarterly frequency.

Table 2: Summary of Option-Adjusted Spread and Rolling-TBA Return

A: OAS							
	Summary				Sample		
Cohort	mean	sd	min	max	Begin	End	N
2.0	28.46	33.70	0.30	98.20	2013/01	2013/07	7
2.5	30.76	28.24	-15.10	82.90	2011/10	2013/07	22
3.0	30.51	27.06	-23.60	79.30	2010/08	2013/07	34
3.5	18.61	18.00	-28.60	49.80	2009/01	2013/07	53
4.0	15.13	13.90	-16.60	71.00	2008/12	2013/07	54
4.5	13.29	20.56	-41.00	81.00	2003/05	2013/07	116
5.0	5.50	26.60	-83.50	79.80	2002/08	2013/07	128
5.5	11.52	26.09	-59.90	108.10	1998/12	2013/07	154
6.0	16.05	29.18	-52.80	143.70	1998/07	2013/07	166
6.5	21.43	36.55	-34.10	183.00	1998/07	2013/07	163
7.0	23.47	41.58	-64.90	222.00	1998/07	2013/07	155
7.5	47.81	72.97	-46.90	329.10	1998/07	2011/07	148
8.0	46.19	94.83	-86.70	329.10	1998/07	2011/04	138
8.5	60.15	93.78	-60.00	308.80	1998/07	2009/06	122
B: TBA Rolling Return							
	Summary				Sample		
Cohort	mean	sd	min	max	Begin	End	N
2.0	-12.09	19.30	-42.25	14.18	2013/01	2013/07	7
2.5	0.42	8.93	-21.59	13.03	2011/10	2013/07	22
3.0	1.99	8.52	-17.09	22.77	2010/08	2013/07	34
3.5	2.23	7.81	-19.42	18.07	2009/01	2013/07	53
4.0	2.23	5.98	-15.55	16.90	2008/12	2013/07	54
4.5	2.35	7.73	-34.22	44.39	2003/05	2013/07	116
5.0	2.34	6.21	-26.76	34.51	2002/08	2013/07	128
5.5	2.46	5.14	-19.02	24.12	1998/12	2013/07	147
6.0	2.48	3.89	-11.67	15.05	1998/07	2013/07	148
6.5	2.57	3.30	-8.56	10.62	1998/07	2013/07	145
7.0	2.33	3.02	-13.06	10.33	1998/07	2013/07	137
7.5	2.00	2.71	-12.40	9.62	1998/07	2011/07	130
8.0	1.89	2.79	-5.66	16.39	1998/07	2011/04	120
8.5	1.69	1.97	-7.05	8.97	1998/07	2009/06	104

Note: The first four columns provide basic summary statistics, including mean, standard deviation (sd), minimum, quartiles, and maximum, for the monthly series of option-adjusted spreads (in basis points) and rolling-TBA returns (in percentage points) for generic TBA cohorts with pass-through rates from 2% to 8.5%. The overall sample period is from July 1998 to July 2013. The various sample periods of individual cohorts, including the beginning month, ending month, and number of monthly observations, are provided in the last three columns.

5 Determinants of Dollar Roll Specialness

In this section we test the two economic channels as determinants of dollar roll specialness. For ease of reference, a glossary of key empirical variables used in this section as well as the subsequent two sections are provided in Appendix C.

5.1 Redelivery risk

In this subsection, we empirically test the effect of redelivery risk on dollar roll specialness. As formalized in Hypothesis 1, we expect that dollar roll specialness increases in redelivery risk. We measure redelivery risk by the value dispersion within the basket of MBS that are likely to be delivered into TBA contracts.

To construct this value dispersion measure, it would be desirable to know which MBS CUSIPs are the most advantageous, or cheapest, to deliver into TBA contracts, among the set of eligible MBS. We follow industry practice as described in Himmelberg, Young, Shan, and Henson (2013) to construct the set of TBA deliverables using data on MBS characteristics introduced in Section 4.2. Specifically, for each TBA cohort in each month, we eliminate MBS CUSIPs that have at least one of the following characteristics: remaining principal balance is less than $150,000, refinance share is greater than 75%, the weighted average original loan-to-value ratio is above 85%, and the weighted average original FICO score is below 680. MBS with these characteristics "that inhibit efficient prepayments command a price premium, and are not delivered into TBAs" (Himmelberg, Young, Shan, and Henson (2013)). The remaining MBS CUSIPs are likely to be delivered into TBA contracts.

We measure the value dispersion of these TBA deliverables by the range (highest minus lowest) of their CUSIP-level realized conditional prepayment rates (as discussed in Section 4.2), denoted as $Disp_i^{CPR}$, for the cohort with pass-through rate i.[18] A high value of

[18] To alleviate the concern on the sensitivity of $Disp_i^{CPR}$ to outliers, we conduct robustness checks using dispersion measures as the 95% percentile relative to the median for in-the-money cohorts and 5% percentile

$Disp_i^{CPR}$ always indicates high redelivery risk, regardless of the MBS being a premium or discount security.[19]

Because data on MBS characteristics start from July 2005, $Disp_i^{CPR}$ is computed from July 2005 to July 2013, for various generic TBA cohorts with moneyness in the range $(-1.75\%, 3.75\%)$. Panel A of Table 3 reports basic summary statistics of prepayment rate dispersion $Disp_i^{CPR}$, in percentage points. The average value of $Disp_i^{CPR}$ across both cohort and time is 56%. By construction, the dispersion measure has a theoretical upper bound of 100% because the highest and lowest possible prepayment rates are 100% and 0%, respectively.

Our analysis of the effect of redelivery risk is based on the following panel regression:

$$Specialness_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta \cdot Disp_{it}^{CPR} + \varepsilon_{it}, \tag{2}$$

where $Specialness_{it}$ is the dollar roll specialness of cohort i and month t, $Disp_{it}^{CPR}$ is the dispersion of conditional prepayment rates for the same cohort and month, and D_t and D_i are time dummies and moneyness dummies, respectively. The time dummies control the effect of certain pure time-series factors and allow us to focus on the cross-sectional variation of dollar roll specialness, whereas the moneyness dummies control the effect of cohort-level factors and allow us to focus on the time-series variation. Using moneyness dummies to control for cohort-level factors is more meaningful than using coupon dummies from a prepayment and economic perspective as the same coupon can have very different prepayment behaviors in different time periods.[20] We report results based on different combinations of time and

relative to the median for out-of-the-money cohorts (weighted by balances), denoted as $Disp^{CPR,\ 5\%}$. We also construct a similar measure using the 90% and 10% percentiles, denoted as $Disp^{CPR,\ 10\%}$. Panel A of Table IA3 show that regression results of dollar roll specialness are as significant as in the baseline results and hence robust.

[19] When $Disp_i^{CPR}$ is higher, a premium MBS lender will be delivered back an MBS of higher prepayment rate and a discount MBS lender will be delivered back an MBS of lower prepayment speed. In dollar rolls, both scenarios imply lower MBS value and higher redelivery risk.

[20] We are grateful to an anonymous referee for the suggestion of using moneyness dummies. We also

Table 3: Summary Statistics of Empirical Measures

A: Basic Summary Statistics

	N	mean	sd	min	p25	p50	p75	max
Disp_{it}^{CPR}	788	0.559	0.354	0.000	0.250	0.507	1.000	1.000
Payup_{it}	218	0.365	0.890	-6.485	0.149	0.291	0.556	5.143
Trade_{it}^{SP}	289	12.882	17.458	0.000	1.397	6.707	17.586	123.067
Leverage_t	158	3.485	4.863	0.380	0.961	1.313	4.666	46.273
$CPR_{it}^{Signed,Change}$	779	0.026	0.149	-0.309	-0.050	0.000	0.058	0.723

B: Pooled Correlation

	Disp_{it}^{CPR}	Leverage_t	$CPR_{it}^{Signed,Change}$
Disp_{it}^{CPR}	1		
Leverage_t	0.0332	1	
$CPR_{it}^{Signed,Change}$	-0.0680	-0.241	1

Note: Panel A reports basic summary statistics, including the number of observations, mean, standard deviation (sd), minimum, quartiles, and maximum, of the dispersion of prepayment rates in percentage points ($Disp_{it}^{CPR}$), the price difference between specified pool and TBA transactions in cents per dollar face value ($Payup_{it}$), the trading volume of specified pools in \$100 million ($Trade^{SP_{it}}$), the leverage measure of primary dealers ($Leverage_t$), and the measure of prepayment exposure transfer ($CPR_{it}^{Signed,Change}$), for cohort i and month t. Panel B reports the pooled correlations of $Disp_{it}^{CPR}$, $Leverage_t$, and $CPR_{it}^{Signed,Change}$. The sample period is July 2005–July 2013 for $Disp_{it}^{CPR}$, May 2011–July 2013 for $Payup_{it}$ and $Trade^{SP_{it}}$, January 2000–July 2013 for $Leverage_t$, and August 2005–July 2013 for $CPR_{it}^{Signed,Change}$.

moneyness dummies. To account for potential serial correlation in the data, we compute robust t-statistics based on panel Newey-West standard errors (Driscoll and Kraay (1998)) using the rule-of-thumb bandwidth choice $T^{1/4}$, which is equal to 4 in our sample.[21] We shall follow these choices in all our empirical analyses.

The first four columns in Panel A of Table 4 report results of the panel regression (2). From the first column, the coefficient on $Disp^{CPR}$ is 1.161 and highly significant with a robust t-statistic of 5.641, without including fixed effects. The second and third columns show that the coefficient is also positive and significant when either time or moneyness fixed

conduct analysis using coupon dummies in Table IA4 of the Internet Appendix and find the results to be qualitatively similar.

[21] Here, T is the number of time series observations. As shown in Table 1, the largest number of time series observations for a cohort is 166, which gives a bandwidth of $166^{1/4} = 3.6$.

Table 4: Redelivery Risk

A: Regress Specialness on Measures of Redelivery Risk								
	Disp=Disp^{CPR}				Disp=Payup			
Disp	1.161***	0.670***	1.981***	1.465***	0.143***	0.136***	0.072	0.035
	(5.641)	(3.382)	(10.132)	(9.596)	(4.585)	(4.999)	(1.266)	(0.723)
Constant	-0.740***	0.108	-0.341	0.883**	0.734***	0.594***	-1.260	-2.148*
	(-5.249)	(0.256)	(-1.074)	(2.251)	(11.246)	(2.885)	(-0.891)	(-1.779)
N	762	762	762	762	218	218	218	218
R^2	0.078	0.376	0.256	0.619	0.089	0.371	0.220	0.513
Moneyness FE	No	No	Yes	Yes	No	No	Yes	Yes
Time FE	No	Yes	No	Yes	No	Yes	No	Yes
B: Equilibrium Relation between Specialness and SP Trading Volume								
Trade^{SP}	0.035***	0.037***	0.009*	0.004				
	(5.082)	(5.330)	(1.768)	(0.760)				
Constant	-0.335**	-0.612	-3.946***	-5.313***				
	(-2.318)	(-1.318)	(-7.496)	(-9.825)				
N	289	289	289	289				
R^2	0.095	0.188	0.560	0.712				
Moneyness FE	No	No	Yes	Yes				
Time FE	No	Yes	No	Yes				

Note: Panel A reports panel regressions of dollar roll specialness on redelivery risk, measured by the dispersion of prepayment rates across CUSIPs in cohort i of month t ($Disp_{it}^{CPR}$) in the first four columns, and measured by the price difference between specified pool and TBA transactions ($Payup_{it}$) in the last four columns. Panel B reports panel regressions of dollar roll specialness on the trading volume ($Trade^{SP_{it}}$) of the specified pools of cohort i and month t. The sample period is July 2005–July 2013 in the first four columns of Panel A. The sample period is May 2011–July 2013 in the last four columns of Panel A and Panel B. Robust t-statistics based on panel Newey-West standard errors of Driscoll and Kraay (1998) with the $T^{1/4}$ bandwidth are reported in parentheses. Significance levels: ** for $p < 0.01$, * for $p < 0.05$, and $^{+}$ for $p < 0.1$, where p is the p-value.

effect is included, implying that dollar roll specialness has significant positive association with $Disp^{CPR}$ on either the time-series or cross-sectional dimension. When both fixed effects are included, the statistical significance of $Disp^{CPR}$ becomes even stronger, as shown in the fourth column. Overall, consistent with Hypothesis 1, the empirical results show that dollar roll specialness is indeed positively associated with redelivery risk, across time series and moneyness cohorts. The economic magnitude is also large. For example, reading from the first column, one standard deviation increase in $Disp^{CPR}$ (as from Table 3) is associated with an increase of about 0.41 percentage points or 41 basis points (= 1.161×0.354) in dollar roll specialness.

While the dispersion of prepayment rates is our main measure of redelivery risk, we also consider a second measure: the difference between the specified pool price and the TBA price. As discussed in Section 3, specified pool trading specifies the deliverable MBS, is not subject to redelivery risk, and hence is more attractive for market participants who seek to finance high-quality MBS. Hence, the specified-pool-versus-TBA price difference, known as "Payup" in practice, is also a proxy for the value dispersion within MBS deliverables. We compute $Payup_{it}$ for the cohort with pass-through rate i in month t as the difference between the average price (weighted by trading volume) of all specified pool trades of MBS eligible for cohort i and the average price (also weighted by trading volume) of TBA trades of cohort i, on the day before the notice day of month t. Similar to $Disp_i^{CPR}$, a high $Payup_{it}$ indicates a higher redelivery risk, regardless of whether the MBS is a premium or discount security.

Panel A of Table 3 reports summary statistics of $Payup_{it}$, in cents per unit dollar face value. Note that the sample size is much smaller than $Disp_i^{CPR}$ as MBS transaction data are only reported through TRACE since May 2011. The average is about 37 cents per \$100 face value, with a standard deviation of 89 cents. The last four columns in Panel A of Table 4 reports the following panel regression:

$$Specialness_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta \cdot Payup_{it} + \varepsilon_{it}. \quad (3)$$

As the sample size of $Payup$ is much smaller than that of $Disp_i^{CPR}$ in the regression (2), the statistical significance is weaker, unsurprisingly. The coefficient on $Payup_{it}$ is statistically significant, estimated to be about 0.14, if the moneyness fixed effect is not included, regardless of whether the time fixed effect is included or not. Reading from the fifth column, a one standard deviation increase in $Payup$ is associated with an increase of specialness by about 0.13 percentage points or 13 basis points ($= 0.143 \times 0.89$). But if moneyness fixed effect is included, the statistical significance on $Payup_{it}$ is lost and the magnitude becomes much smaller. Overall, a higher $Payup_{it}$ tends to be associated with a higher specialness in the cross sectional dimension, supporting the redelivery-risk channel of Hypothesis 1.

Finally, as formalized in Hypothesis 2, the existence of specified pool trading leads to a positive relation between dollar roll specialness and specified pool trading volume. We measure specified pool trading volume $Trade_{it}^{SP}$ for cohort i in month t by the total dollar trading volume of specified pool MBS that are eligible for delivery into cohort i on the day before the notice day in month t. Panel A of Table 3 reports summary statistics of $Trade_{it}^{SP}$, in units of \$100 million. The average is about \$1.3 billion, with a standard deviation of 1.7 billion.

Panel B of Table 4 reports the panel regressions of dollar roll specialness on $Trade^{SP}$:

$$Specialness_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta \cdot Trade_{it}^{SP} + \varepsilon_{it}. \tag{4}$$

Consistent with Hypothesis 2, the coefficient on $Trade_{it}^{SP}$ is positive, hence higher specified pool trading volume is positively associated with higher dollar roll specialness. The statistical significance is strong without moneyness dummies, but is weaker when moneyness dummies are included. Economically, reading from the first column of Panel B, a one standard deviation increase in $Trade_{it}^{SP}$ is associated with an increase of 0.61 percentage points or 61 basis points ($= 0.035 \times 17.458$) in specialness, slightly larger than the economic magnitude of $Disp^{CPR}$ reported above.

In sum, using two different measures of redelivery risk, our results confirm the importance of redelivery risk in driving dollar roll specialness. Our results also quantify the equilibrium relationship between dollar roll and specified pool trading in MBS markets.

5.2 Ownership exchange

In this section, we empirically test the effect of ownership exchange on dollar roll specialness. As discussed in Section 3, dollar rolls provide off-balance sheet financing, whereas repos remain on the balance sheet. As stated in Hypothesis 3, dollar roll specialness negatively depends on the leverage constraint of financial institutions that are important in MBS markets. To measure leverage constraints, we follow He, Kelly, and Manela (2017) and use the lagged squared aggregate asset/equity ratio of the bank holding companies of primary dealers, labeled Leverage.[22] Panel A of Table 3 reports summary statistics of Leverage over time series.

We expect that as primary dealers' leverage increases, they are more inclined to finance their MBS positions by selling dollar rolls to remove them from the banks' balance sheet temporarily. The resulting downward price pressure on the front-month TBA contract, relative to the future-month TBA contract, implies a higher effective financing rate and hence a lower specialness. Therefore, we expect a negative relation between dollar roll specialness and Leverage.

Panel A of Table 5 reports the following panel regression:

$$Specialness_{it} = \sum_i \gamma_i D_i + \beta \cdot Leverage_{t-1} + \varepsilon_{it}, \tag{5}$$

where we use one-month lagged value of Leverage and only include moneyness dummies. (Obviously, since Leverage is a pure time-series variable, adding time dummies would absorb the interesting variations in leverage constraint that we are interested in.) Consistent with Hypothesis 3, the coefficient on Leverage is negative and highly significant, regardless whether or not moneyness dummies are included. The economic magnitude is also large. A one standard deviation increase of Leverage is associated with a decrease of specialness

[22] Squaring the leverage ratio is motivated by theory. See the discussion in He, Kelly, and Manela (2017).

Table 5: Ownership Change

A: Leverage Constraint			B: Prepayment Exposure Transfer				
Leverage	-0.023**	-0.057***	$CPR_{it}^{Signed,Change}$	-1.413***	-1.694***	-1.498***	-0.785**
	(-1.972)	(-6.098)		(-2.825)	(-3.528)	(-3.221)	(-1.976)
Constant	0.136	1.847***	Constant	-0.039	0.095	0.806**	1.655***
	(1.616)	(2.739)		(-0.475)	(0.262)	(2.126)	(3.922)
N	1,341	1,341	N	760	760	760	760
R^2	0.008	0.318	R^2	0.022	0.121	0.385	0.561
Moneyness FE	No	Yes	Moneyness FE	No	Yes	No	Yes
Time FE	No	No	Time FE	No	No	Yes	Yes

Note: Panel A reports panel regressions of dollar roll specialness on the leverage measure of the bank holding companies of primary dealers ($Leverage_t$), whereas Panel B reports panel regressions of dollar roll specialness on the measure of prepayment exposure transfer ($CPR_{it}^{Signed,Change}$), for cohort i and month t. The sample period is July 1998–July 2013 in Panel A and July 2005–July 2013 in Panel B. Panel A considers the specifications with no dummies and only the moneyness dummies, while Panel B considers all four specifications with different combinations of moneyness and time dummies. Robust t-statistics based on panel Newey-West standard errors of Driscoll and Kraay (1998) with the $T^{1/4}$ bandwidth are reported in parentheses. Significance levels: ** for $p < 0.01$, * for $p < 0.05$, and $^{+}$ for $p < 0.1$, where p is the p-value.

about of 0.11 percentage points or 11 basis points ($= 0.023 \times 4.863$).

The second effect of ownership exchange in dollar rolls is that the roll buyer takes over the prepayment exposure over the funding period. Therefore, as stated in Hypothesis 4, the unfavorable prepayment profile of the MBS collateral will lead the roll buyer to charge a high financing rate, hence lower specialness. For premium (discount) MBS, the higher (lower) is the prepayment rate than expected, the worse prepayment profile of the MBS collateral is to the roll buyer.

To capture the unfavorable prepayment exposure of the dollar roll buyer during the funding period, we first compute the difference between the average realized prepayment rate across all TBA deliverables in cohort i at month t and the Bloomberg median prepayment rate forecast for cohort i and month t (see Section 4.2). This difference is denoted ΔCPR_{it}, similar to Diep, Eisfeldt, and Richardson (2017).[23] As the Bloomberg median prepayment rate forecast is available at the daily frequency, we use the value on the day before the notice day of each month. We then define a signed measure that equals ΔCPR_{it} for premium MBS and $-\Delta CPR_{it}$ for discount MBS, denoted $CPR_{it}^{Signed,Change}$, so that an increase of $CPR_{it}^{Signed,Change}$ indicates a less favorable prepayment exposure to the roll buyer.

Panel B of Table 5 reports the following panel regression:

$$Specialness_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta \cdot CPR_{it}^{Signed,Change} + \varepsilon_{it}. \tag{6}$$

Note that we are not trying to predict specialness but want to understand, ex post, if shocks in prepayment speed matter for specialness by affecting the roll buyer's prepayment exposure. Hence, the fact that $CPR_{it}^{Signed,Change}$ uses realized prepayment data available at the month end does not affect the interpretation of the regression. (The results using a measure of $specialness_{it}$ computed using the month-t realized prepayment rate, which is aligned with $CPR_{it}^{Signed,Change}$, are roughly the same.)

Consistent with Hypothesis 4, we find that the coefficient on $CPR_{it}^{Signed,Change}$ is consistently negative and significant in all specifications with various combinations of moneyness and time dummies, even with both time and moneyness dummies. Reading from the first column in Panel B of Table 5, one standard deviation increase in ΔCPR_{it}^{signed} (as from Table 3) is associated with a decrease of about 0.21 percentage points or 21 basis points ($= 1.413 \times 0.149$) in dollar roll specialness.

[23] Given that the Bloomberg survey provides long-term projections and prepayment are mean reverting and persistent, ΔCPR_{it} may understate (overstate) expected prepayment rates when current prepayment rates are high (low). We conduct robustness checks by measuring ΔCPR_{it} as the difference between the realized prepayment rate at month t and the realized prepayment rate at month $t-1$. As the prepayment rate is usually persistent. the lagged realized prepayment rate is likely a reasonable proxy for the expected prepayment rate next period. Importantly, this measure uses only monthly prepayment rates and hence is not subject to the caveat of using Bloomberg forecast. Panel B of Table IA3 in the Internet Appendix using this alternative measure confirms the significant dependence of dollar roll specialness on prepayment exposure transfer.

Overall, our results show strong effects of ownership exchange on dollar roll specialness, by relaxing leverage constraints of financial institutions and by transferring prepayment exposure during the funding period.

5.3 Multivariate regressions

The analyses in the previous subsections separately investigate redelivery risk and ownership exchange. In this section, we conduct a multivariate regression by putting both economic factors together.

In particular, Table 6 shows the following panel regressions:

$$\begin{aligned} Specialness_{it} &= \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta_1 \cdot Disp_{it}^{CPR} + \beta_2 \cdot Leverage_{t-1} \\ &+ \beta_3 \cdot CPR_{it}^{Signed,Change} + \varepsilon_{it}. \end{aligned} \tag{7}$$

That is, for redelivery risk, we use the dispersion of prepayment speed $Disp_{it}^{CPR}$ because it has much larger sample coverage than $Payup_{it}$. Moreover, $Leverage_t$ will be excluded from the regression if time dummies are included.

From column (1) where no dummy variables are included, the coefficients on $Disp_{it}^{CPR}$, $Leverage_{t-1}$, and $CPR_{it}^{Signed,Change}$ are 1.39, -0.052, and -2.005, respectively. They are remarkably close to the coefficients in univariate regressions (1.168, -0.035, and -1.550, respectively). Column (2) shows that these three factors are still highly significant in affecting dollar roll specialness in the time series if only moneyness dummies are included. If time dummies are included, either alone or in addition to moneyness dummies, both $Disp_{it}^{CPR}$ and $CPR_{it}^{Signed,Change}$ remain significant, as shown in columns (3) and (4).

In addition, to check the results in a longer sample period, we consider an alternative but cruder measure of redelivery risk, namely the expected prepayment speed. Intuitively, if no borrower ever prepays, MBS values in the same cohort should be identical, despite the

Table 6: Multivariate Regression of Dollar Roll Specialness

Variables	(1)	(2)	(3)	(4)	Variables	(5)
Disp^{CPR}	1.168***	1.893***	0.630***	1.597***	$CPR^{forecast}$	3.503***
	(5.796)	(9.753)	(3.225)	(10.522)		(7.015)
Leverage	-0.035***	-0.019*			Leverage	-0.051***
	(-3.085)	(-1.950)				(-5.844)
$CPR^{Signed,Change}$	-1.550***	-1.312***	-1.351***	-0.727**		
	(-3.297)	(-3.185)	(-2.967)	(-2.129)		
Constant	-0.514***	-0.285	-0.039	1.056***	Constant	-1.867***
	(-3.384)	(-0.898)	(-0.096)	(2.732)		(-6.132)
N	760	760	760	760		1,331
R^2	0.118	0.278	0.422	0.639		0.374
Moneyness FE	No	Yes	No	Yes		Yes
Time FE	No	No	Yes	Yes		No

Note: The first four columns report multivariate panel regressions of dollar roll specialness on the measure of redelivery risk ($Disp_{it}^{CPR}$), the leverage measure of primary dealers ($Leverage_t$), and the measure of prepayment exposure transfer ($CPR_{it}^{Signed,Change}$), for cohort i and month t. The overall sample period is July 2005–July 2013. We consider all four specifications with different combinations of moneyness and time dummies. The last column reports the panel regression of dollar roll specialness on the Bloomberg median prepayment rate forecast ($CPR_{it}^{forecast}$) as well as $Leverage_t$, where the sample period is January 2000–July 2013 and only the moneyness dummy is included. Robust t-statistics based on panel Newey-West standard errors of Driscoll and Kraay (1998) with the $T^{1/4}$ bandwidth choice are reported in parentheses. Significance levels: ** for $p < 0.01$, * for $p < 0.05$, and $^{+}$ for $p < 0.1$, where p is the p-value.

potential difference in MBS characteristics such as the underlying borrowers' sensitivity to interest rate. Only if borrower prepay do we expect to observe a value dispersion of MBS in a cohort. The dispersion increases in the prepayment speed henceforth.[24] To measure the expected prepayment speed, we use the Bloomberg median prepayment rate forecast, denoted as $CPR_{it}^{forecast}$ for cohort i and month t, which is available from July 1998 to July 2013. Column (5) reports regressions of dollar roll specialness on $CPR_{it}^{forecast}$ and $Leverage_{t-1}$. As expected, the coefficients on $CPR_{it}^{forecast}$ and $Leverage_{t-1}$ are positive and negative, respectively. Both are also highly significant with t-statistics larger than 5. The

[24]In an earlier version of the paper, we have a simple model that provides a microfoundation to this claim.

evidence from these alternative measures over a longer time period confirms the effects of redelivery risk and leverage constraint on dollar roll specialness.

One potential concern of our regressions in this section is that the specialness measure uses the prepayment model of one large bank, J.P. Morgan. In Table IA1 of the internet appendix, we use an alternative measure of specialness based on historical prepayment rates in regression (7). This alternative measure is likely to capture expected prepayments on average over a decent sample. Importantly, it does not depend on an assumed prepayment model. The results in Table IA1 confirm the robustness of our main results on the determinants of dollar roll specialness.[25]

6 Dollar Roll Specialness and MBS Returns

In this section, we investigate the relation between doll roll specialness and MBS returns. As formalized in Hypothesis 5, we expect a negative relation, as an MBS holder is willing to accept a lower expected return in the cash market when the low financing rate or high specialness brings in a "convenience yield" in the financing market.

Panel A of Table 7 reports the following panel regression:

$$OAS_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta \cdot Specialness_{it} + \epsilon_{it}, \tag{8}$$

where we use the option-adjusted spread OAS_{it} for cohort i in month t as a proxy for expected MBS returns. The coefficient on Specialness is negative and highly significant, regardless of whether moneyness and time dummies are included. The magnitude of the coefficient is quite stable across specifications with different dummies, with one percentage point increase

[25] In the internet appendix, we also examine a few other potential factors that may affect dollar roll specialness. They include the credit spread of J.P. Morgan, settlement failures, interest rate volatility, and Treasury-MBS repo spread. These factors generally have no or marginal significant explanatory power for dollar roll specialness.

of specialness associated with 15–20 basis points decrease in OAS.

One potential concern with the regression (8) is that OAS and specialness are both calculated from a prepayment model, which may raise model misspecification and endogeneity concerns. We address these concerns in two ways. First, we use the dollar roll financing rate based on realized prepayment rates, rather than forecasted prepayment rates from a prepayment model, to calculate specialness, denoted $Specialness_{it}^{Hist}$. Panel B of Table 7 reports results of the regression (8) with dollar roll specialness measured by $Specialness_{it}^{Hist}$. As before, there is a statistically significant and negative relation between dollar roll specialness and OAS, though the magnitude becomes smaller. One percentage point increase of specialness is associated with about 15–19 basis points decrease in OAS. The magnitude of the coefficient is also stable across specifications with different dummies. In addition, in Table IA1 of the internet appendix we use the OAS measure from Barclays, and the results are similar.

Second, we use the rolling-TBA return as a measure of MBS return in the regression:

$$Ret_{it}^{TBA} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta \cdot Specialness_{it} + \epsilon_{it}, \tag{9}$$

where Ret_{it}^{TBA} is the one-month return of a rolling strategy in the TBA cohort i. As discussed in Section 4.4, Ret_{it}^{TBA} does not depend on any model or assumption about mortgage prepayment rates or interest rate paths. The results of regression (9), presented in panel C of Table 7, further confirm the negative relation between dollar roll specialness and MBS returns. In particular, the coefficient on specialness is negative and highly significant with robust t-statistics above 2.6. One percentage point increase of specialness is associated with 20–46 basis points decrease in rolling-TBA returns, which is of similar economic magnitude to the regression (8).

Overall, our results using various measures of specialness and MBS returns all confirm

Table 7: Dollar Roll Specialness and MBS Returns

A: Regress OAS on Expected Specialness				
Specialness	-18.331***	-15.627***	-20.146***	-15.098***
	(-15.181)	(-13.610)	(-17.891)	(-14.167)
Constant	27.967***	15.534	6.158	2.804
	(10.274)	(1.552)	(0.423)	(0.179)
N	1,460	1,460	1,460	1,460
R^2	0.261	0.359	0.580	0.652
Moneyness FE	No	Yes	No	Yes
Time FE	No	No	Yes	Yes
B: Regress OAS on Realized Specialness				
$Specialness^{Hist}$	-18.097***	-15.076***	-18.750***	-13.640***
	(-15.346)	(-13.289)	(-17.028)	(-13.067)
Constant	26.343***	15.734	3.906	0.424
	(9.656)	(1.553)	(0.265)	(0.027)
N	1,460	1,460	1,460	1,460
R^2	0.259	0.345	0.569	0.640
Moneyness FE	No	Yes	No	Yes
Time FE	No	No	Yes	Yes
C: Regress Rolling-TBA Return on Expected Specialness				
Specialness	-0.363***	-0.459***	-0.206***	-0.352***
	(-3.976)	(-4.995)	(-2.614)	(-4.186)
Constant	2.185***	2.447***	-5.115***	-4.943***
	(14.153)	(3.066)	(-4.735)	(-4.129)
N	1,345	1,345	1,345	1,345
R^2	0.012	0.031	0.520	0.530
Moneyness FE	No	Yes	No	Yes
Time FE	No	No	Yes	Yes

Note: Panel A reports panel regression of the option-adjusted spread (in basis points) on the specialness measure (in percentage points) calculated through a prepayment model. Panel B reports panel regressions of the option-adjusted spread on the specialness measure calculated using realized prepayment rates. Panel C reports panel regressions of the one-month rolling-TBA returns on the specialness measure calculated through the prepayment model. For each panel, we consider all four specifications with different combinations of moneyness and time dummies. Robust t-statistics based on panel Newey-West standard errors of Driscoll and Kraay (1998) with the $T^{1/4}$ bandwidth choice are reported in parentheses. Significance levels: ** for $p < 0.01$, * for $p < 0.05$, and $^{+}$ for $p < 0.1$, where p is the p-value. The overall sample period is January 2009–July 2013. The overall sample period in Panels A and B is July 1998–July 2013, while that in Panel C is January 2000–July 2013 that spans the maximum availability of the rolling-TBA returns.

the hypothesis that dollar roll specialness and MBS returns are negatively related.

7 The Federal Reserve's Use of Dollar Rolls During Quantitative Easing

In response to the financial crisis, the Federal Reserve conducted a sequence of outright purchase programs of agency MBS (and Treasury securities) for the purpose of "credit easing" (Bernanke (2009)). The first MBS purchase program was announced in November 2008, and executed from January 2009 to March 2010, with a total size of around $1.25 trillion as planed and hence a pace of about $80 billion per month. The second purchase program started in September 2011, with the monthly purchase amount equal to the amount of principal payments from the Federal Reserve's agency MBS holdings. The third purchase program started in September 2012 at a pace of $40 billion per month. The second and third purchase programs have been running until the end of our sample period, i.e., July 2013, with a monthly outright purchase amount of about $45–55 billion. On December 18, 2013, the Fed began "tapering" its asset purchases, with a reduction of $5 billion per month on MBS purchases. The scheduled MBS purchases ended in October 2014, although the Fed continues reinvesting in MBS the principal and coupon payments from its existing holdings, as of this writing.

The Fed's MBS purchases were executed exclusively in the TBA market. During the purchase programs, both practitioners and policy makers are concerned that the large MBS purchases may lead to temporary shortage of MBS collateral, if the MBS production cannot keep up with the Fed's purchase pace. Such collateral shortage may disrupt portfolio allocation, risk management, and inventory adjustment of large MBS investors such as commercial banks, insurance companies, mutual funds, and broker-dealers. To mitigate these potential market "disruptions," the Fed announced that it would conduct dollar roll transactions to reduce collateral shortage. On its web site, the Federal Reserve Bank of New York writes:[26]

> "Based on the directive from the FOMC, the Desk may conduct dollar rolls in order to facilitate settlement associated with its unsettled agency MBS purchases. Selling dollar rolls effectively postpones the settlement of outstanding forward purchase commitments, while buying dollar rolls effectively brings settlement forward. Dollar rolls would typically be conducted only if implied financing rates on agency MBS are notably below or above the general level of short-term interest rates, as such conditions may signal a shortage or abundance of supply, respectively, available for settlement."

The Fed's public communication indicates an additional channel that may affect specialness: the available supply of MBS collateral. Because supply shortage affects both the settlement of dollar rolls and the settlement of MBS repos, it is not a priori obvious how supply affects dollar roll specialness. For this channel to work in the intended direction, each dollar of increased MBS supply must reduce the settlement pressure in dollar rolls by more than it reduces that in MBS repos. Moreover, increasing MBS supply in the market also weakly increases the value of the cheapest-to-deliver option, which tends to make dollar rolls *more* special. Finally, by selling dollar rolls, the Fed also changes the composition of cash versus MBS in the balance sheets of market participants. If it increases leverage of financial institutions, we would expect to see lower specialness from the channel of balance sheet relief. Combining all these confounding and conflicting channels, whether selling dollar rolls reduces specialness remains an empirical question, which we aim to answer in the remaining of this section.

[26]See `http://www.ny.frb.org/markets/ambs/ambs_faq.html` for details.

7.1 Summary of the Federal Reserve's MBS operations

We obtain the Federal Reserve's transactions data of the FNMA 30-year MBS with different TBA cohorts from the web site of the Federal Reserve Bank of New York. To put the Fed's MBS purchases into context, we also obtain the monthly new issuance and outstanding balance of FNMA 30-year MBS, both from eMBS. For the cohorts in which the Fed conducted MBS purchases from January 2009 to July 2013, Panel A of Table 8 reports the outstanding balance as of December 2008 (the month right before the Fed's MBS purchase programs started), the cumulative new issuance from January 2009 to July 2013, and the cumulative outstanding balance computed as the sum of the first two. We observe that the outstanding balance as of December 2008 is much larger for cohorts of higher pass-through rates, especially the 5–6% cohorts that were production coupons at that time. In contrast, the cumulative issuance is much larger for cohorts of lower pass-through rates, as the primary mortgage rate decreased in the period January 2009–July 2013 (as shown in Figure 3) and new MBS issuance shifted towards lower coupon rates. Yet, the cumulative issuance for the 2.5% cohort is low because it only became active in production in the very end of our sample period. As the sum of the first two measures, the cumulative outstanding balance appears more balanced across cohorts.

Panel B of Table 8 reports summary statistics of the Fed's outright purchases. From the first column, the number of months during which the Fed conducted outright MBS purchases in cohorts of 3%–6% is larger than that in cohorts of 2.5% and 6.5%. As announced publicly, the Fed concentrated their purchases on newly issued MBS of production coupons that are close to concurrent primary mortgage rates. As a result, the 6.5% cohort and the 2.5% cohorts are purchased in relatively few months because the primary mortgage rates were between them for most of the sample (see Figure 3 for the time series of the primary mortgage rate). The second column reports the total outright purchase amount, in billions of dollars, across moneyness cohorts. Consistent with the number months in which the Fed conducted

Table 8: Summary of the MBS Supply and Fed's MBS Operations

A: Summay of Outstanding Balance and New Issuance

Cohort	OB as of 12/2012 ($ billion)	Cumulative Issuance ($ billion)	Cumulative OB ($ billion)
2.5	0.000	12.21	12.21
3	0.002	356.2	356.2
3.5	0.0818	385.0	385.1
4	0.721	453.5	454.2
4.5	46.58	547.9	594.5
5	384.1	204.8	588.9
5.5	650.5	45.79	696.3
6	448.5	20.79	469.2
6.5	137.0	8.043	145.0

B: Summay of the Fed's Outright Purchase

Cohort	Number of Months	Total Purchase ($ billion)	Total Purchase to Cumulative Issuance	Total Purchase to Cumulative OB
2.5	7	8.240	0.675	0.675
3	17	243.3	0.683	0.683
3.5	26	212.7	0.552	0.552
4	27	200.3	0.442	0.441
4.5	20	300.9	0.549	0.506
5	18	318.7	1.556	0.541
5.5	19	401.1	8.759	0.576
6	14	67.59	3.250	0.144
6.5	9	4.211	0.524	0.029

C: Summary of the Fed's Dollar Roll Sales

Cohort	Total Roll Sale ($ billion)	Total Roll Sale to Total Purchase	Monthly Average of Roll Sale/Purchase
2.5	0.000	0.000	0.000
3	2.505	0.010	0.007
3.5	41.42	0.195	0.164
4	14.19	0.071	0.025
4.5	11.01	0.037	0.025
5	187.7	0.589	0.556
5.5	268.0	0.668	0.704
6	44.51	0.659	0.466
6.5	2.040	0.484	0.665

Note: For the cohorts of FNMA 30-year MBS in which the Fed conducted outright purchases from January 2009 to July 2013, panel A reports the outstanding balance (in $billion) as of December 2008 (the month right before the Fed's MBS purchase programs started), the cumulative new issuance (in $billion) from January 2009 to July 2013, and the cumulative outstanding balance (in $billion) computed as the sum of the first two. Panel B reports the number of months during which the Fed conducted outright MBS purchases, the total outright purchase amount (in $billion), the ratio of the total purchase amount to the cumulative new issuance, and the ratio of the total purchase amount to the cumulative outstanding balance. Panel C reports the amount of dollar roll sales (in $billion), the ratio of the total amount of dollar roll sales to the total outright purchase amount, and the time-series monthly average of the ratio of the total amount of dollar roll sales to the total outright purchase amount.

outright purchases, the outright purchase amount is higher in cohorts of 3%–6%, ranging from about $70 to $400 billions, whereas the outright purchase amount is less $9 billion in the cohorts of 2.5% and 6.5%.

The third column in Panel B reports the ratio of the total purchase amount to the cumulative new issuance. We observe that the ratio is about 50–60% and stable across cohorts of 2.5%–4.5%, but significantly higher in cohorts of 5%, 5.5%, and 6%, reaching as high as above 800%. This is not surprising as these were the major cohorts involved in the first MBS purchase program at a pace of about 80 billion per month, with which the new issuance could not keep up. In contrast, the 6.5% cohort was only purchased at the very beginning of the first MBS purchase program when new issuance was ample relative to the purchase amount. Furthermore, the fourth column reports the ratio of the total purchase amount to the cumulative outstanding balance. Cumulative outstanding balance is analogous to total Fed purchase because neither deducts the principal payments from MBS. We observe that this ratio is fairly homogeneous across different cohorts, though being low for the 6% and 6.5% cohorts because of the large outstanding balance before January 2009.

Panel C of Table 8 reports summary statistics of the Fed's net dollar roll sales (i.e., dollar roll sales minus dollar roll purchases). In our sample, the Fed very rarely did any dollar roll purchase, consistent with the market concern at the time about the shortage of MBS supply, rather than the abundance of supply. From the first column, we observe that the Fed conducted the largest amounts of dollar roll sales in the cohorts of 5% and 5.5%, which have the largest outright purchase amounts. The second and third columns report the ratio of the total amount of dollar roll sales to the total outright purchase amount and the monthly average of this ratio, respectively. We observe that both are higher in the cohorts of 5%–6.5%, which are the major cohorts involved in the first MBS purchase program and experienced a fast monthly pace of purchase.

7.2 Do the Fed's dollar roll Sales reduce settlement pressure?

In the data, the Fed predominantly sells dollar rolls several days before the settlement day of a month, presumably because it observes heightened specialness in the market. To study whether the Fed's dollar roll sales mitigate the funding distortions in MBS markets, we measure how dollar roll specialness changes after versus before the Fed sells dollar roll. Specifically, we define $\Delta Specialness_{it}$ to be the specialness one day before the settlement day of month t, minus the specialness of one day before the first day when the Fed conducted dollar roll sales for settlement month t, all for cohort i. Note that this calculation involves specialness measured at daily frequency, between the two settlement dates of month $t-1$ and t.

We run the following regression

$$\Delta Specialness_{it} = \sum_t \alpha_t D_t + \beta_1 \cdot d_{it}^{Roll} + \varepsilon_{it}, \tag{10}$$

where d_{it}^{Roll} is a dummy that equals 1 if the Fed conducted any dollar roll sales in cohort i for settlement in month t and equals zero otherwise. Regression (10) is similar to a Bertrand, Duflo, and Mullainathan (2004) type panel regression but using the difference series directly. The coefficient β_1 captures the change of specialness (from before to after the Fed's month-t dollar roll sales) of the cohort that were involved in the Fed's month-t roll sales, on top of the simultaneous change in cohorts that were not involved in the Fed's month-t roll sales. If the Fed's use of dollar rolls as a policy tool is effective, then β_1 should be negative.

The first column of Table 9 reports the regression (10) for the sample of January 2009–July 2013, after the start of the Fed's QE program. We observe that the coefficient on d_{it}^{Roll} is indeed negative and statistically significant. The second column add the changes of two factors that have been shown to affect dollar roll specialness in previous sections, $Disp^{CPR}$ and $CPR^{Signed,Change}$, while the third column further adds changes of specialness and out-

Table 9: Effect of the Fed's Dollar Roll Sales

	$\Delta Specialness_{i,t}$	$\Delta Specialness_{i,t}$	$\Delta Specialness_{i,t}$	$\Delta Specialness_{i,t}$
d_{it}^{roll}	-0.521**	-0.561**	-0.563**	-0.354**
	(-2.042)	(-2.161)	(-2.132)	(-2.275)
$\Delta Disp_t^{CPR}$		0.026	0.048	-0.136
		(0.075)	(0.136)	(-0.443)
$\Delta CPR_t^{Signed,Change}$		-1.459**	-1.441**	-2.190
		(-2.135)	(-2.093)	(-1.298)
$\Delta Specialness_{i,t-1}$			0.022	
			(0.647)	
$\Delta Q_{i,t}^{outright}$			-0.003	
			(-0.271)	
ΔLeverage				-0.049***
				(-2.929)
Constant	0.542	-7.088***	-6.982***	0.812**
	(0.731)	(-12.692)	(-12.005)	(2.064)
N	603	595	585	595
R^2	0.673	0.677	0.677	0.476
Time FE	Yes	Yes	Yes	No

Note: This table reports regressions of the difference between the specialness one day before the settlement day of month t and the specialness one day before the first day when the Fed conducted dollar roll sales of month t in cohort i ($\Delta Specialness_{it}$) on a dummy d_{it}^{Roll} that equals 1 if the Fed's month-t dollar roll sales are in cohort i and equals zero if not. We also control for changes of $Disp^{CPR}$ and $CPR^{Signed,Change}$, as well as changes of specialness and the amount of the Fed's outright purchase in the previous month. Time dummies are included. Robust t-statistics based on panel Newey-West standard errors of Driscoll and Kraay (1998) with the $T^{1/4}$ bandwidth choice are reported in parentheses. Significance levels: ** for $p < 0.01$, * for $p < 0.05$, and $^{+}$ for $p < 0.1$, where p is the p-value. The overall sample period is January 2009-July 2013.

right purchase in the previous month to control for the possibility that the Fed's choice of moneyness cohorts in which it conducts dollar roll sales may be affected by specialness or outright purchases in the past:

$$\begin{aligned}\Delta Specialness_{it} &= \sum_t \alpha_t D_t + \beta_1 \cdot d_{it}^{Roll} + \beta_2 \cdot \Delta Disp_{it}^{CPR} + \beta_3 \Delta CPR_{it}^{Signed,Change} \\ &+ \beta_4 \cdot \Delta Specialness_{i,t-1} + \beta_5 \Delta Q_{i,t}^{outright} + \varepsilon_{it}. \end{aligned} \quad (11)$$

With these additional controls, the coefficient on d_{it}^{Roll} remains negative and highly significant, showing that the effect of the Fed's dollar roll sales on specialness is robust. The economic magnitude is also stable and large across the four regression specifications. The β_1 estimates suggest that the specialness decreased by about 50 basis points after the Fed's dollar roll sales.

Finally, the fourth column of Table 9 adds the change of primary dealers' leverage as a control but removes the time fixed effect. The coefficient on d_{it}^{Roll} is, again, negative and significant, though the magnitude is slightly smaller.

8 Conclusion

Mortgage dollar roll is the most widely used trading strategy for financing agency MBS, accounting for about a half of the trading volume in agency MBS markets. It is also an important policy tool that the Federal Reserve uses in conducting its unconventional monetary policy. Essentially secured loans, dollar rolls differ from repos in two important ways. First, the cash lender (roll buyer) who receives MBS collateral in a dollar roll transaction has the option to return different MBS collateral when the loan matures, a channel we call redelivery risk. Second, the ownership of the MBS collateral is effectively transferred from the roll seller to the roll buyer during the financing period, a channel we call ownership exchange. Reflecting these differences, dollar roll specialness is the MBS repo rate minus the implied dollar roll financing rate, and is therefore a key indicator of the funding markets of agency MBS.

Evidence supports the two economic channels as determinants of dollar roll specialness. Using proprietary data sets from July 1998 to July 2013, we find that dollar roll specialness increases in dispersion of prepayment speeds within MBS cohorts, decreases in the leverage of primary dealers, and decreases in the prepayment risk exposure borne by the roll buyer during the financing period. All of these are consistent with our hypotheses. Unsurprising, specialness is also decreasing in expected MBS returns.

We explore the Federal Reserve's use of dollar roll sales during the implementation of its unconventional monetary policy since the 2008 financial crisis. By selling dollar rolls and delaying taking delivery of agency MBS, the Fed aims to mitigates supply shortage caused by the outright purchases. We find that after the Fed's dollar roll sales, specialness in affected moneyness cohorts fell significantly, relative to moneyness cohorts in which the Fed did not conduct dollar roll sales. The evidence suggests that, as intended, the Fed's sale of dollar rolls effectively mitigates (real or perceived) the supply shortage in agency MBS markets during its QE programs.

Appendices

A A Worked Example of Implied Dollar Roll Financing Rate

In this appendix we present a worked example for the calculation of dollar roll financing rates in Table A1, corresponding to the dollar roll transaction of Figure 2 (see Hayre (2001), Hayre and Young (2004), and Chaudhary (2006) for more complicated examples of dollar roll calculations).

In this example, an investor sells a May/June dollar roll of \$1 million FNMA 30-year 5% coupon MBS, with the price drop of 14/32. We assume that the scheduled principal payment in May is \$1000 and the annualized conditional prepayment rate (CPR) is 10%. (The CPR gives the expected prepayment in a way we detail shortly.) Moreover, the 1-month reinvestment rate over the roll tenor for the roll seller is $r = 2\%$. According to the trading convention, the principal and coupon payments of May are made on June 25.

Cash flows from holding on the \$1 million FNMA 30-year 5% coupon MBS are presented in Panel B of Table A1. The investor will receive \$13,899.54 in total on June 25, including coupon payments of \$4166.67, scheduled principal payments of \$1000, and prepaid principal payments of (with a 10% CPR) \$8732.87.[27] The discounted proceeds as of June 16 is hence \$13,892.99, using the 1-month short rate of 2%.

Panel C tabulates the cash flows from rolling the \$1 million FNMA 30-year 5% coupon MBS. The investor will receive \$1,025,000 on May 16 by selling the MBS in the front month TBA contract at 102-16, along with 14 days accrued coupon payments of \$1944.44 by holding the MBS until May 16, giving a total of \$1,026,944.44. By reinvesting the proceeds at the rate $r = 2\%$, the investor receives the cash inflow of \$1,028,656.01 on June 16. Furthermore, on June 16, the roll seller buys back the amount left after the scheduled and prepaid principal payments, i.e., \$990,267.13 at the price of 102-2, leading to a cash outflow of \$1,010,691.39.[28] Moreover, the roll seller delivers 15 days accrued coupon payments of \$2.063.06 to the roll buyer as the buyer holds the MBS from June 1 to June 16. In total, the roll seller has a cash outflow of \$1,012,754.45 on June 16, with the net cash flow from the whole roll transaction as \$15,901.56 on June 16.

Overall, the investor earns an additional \$2,008.57 by rolling her MBS instead of holding onto it, with the 1-month reinvestment rate equal to 2%. The effective dollar roll financing rate can be solved as the reinvestment rate r that equates the cash flows from rolling the MBS and those from holding onto it. That is, r solves

$$1,026,944.44 \times (1 + r \times 30/360) - 1,012,754.45 = 13,892.99,$$

[27] The \$8732.87 prepayment is calculated as $SMM \times (1,000,000 - 1,000)$ given a 10% CPR.

[28] In practice, the roll seller buys back more than the amount left after the scheduled and prepaid principal payments due to the Good Delivery requirement that the returned MBS pool has a maximum principal difference of 0.01%. The simpler example here is just for the convenience of calculation.

Table A1: Dollar Roll Calculation

A: Assumptions		
Security	FNMA 5% 30-Year	
Principal Balance	$1 million	
Conditioal Prepayment Rate (CPR)	10	
Scheduled Principal Payment	$1000	
Front-Month TBA Price	102-16	
Future-Month TBA Price	102-2	
Roll "Drop"	14/32	
Prevailing Interest Rate (e.g., LIBOR)	2%	
Implied Finance Rate	r	
B: Cash Flows from Holding the MBS		
June 25	Receive coupon payments (5%*30/360*1,000,000)	$4166.67
	Receive Scheduled Principal	$1000
	Receive Prepaid Principal (with 10% CPR)	$8732.87
		$13,899.54
June 16	Discounted Proceeds as of June 16 ($\frac{13{,}899.54}{1+(2\%*9/360)}$)	**$13,892.99**
C: Cash Flows from Rolling the MBS		
May 16	Sell $1,000,000 FNMA 5% at 102-16	$1,025,000.00
	Receive 14 days accrued coupon payments (5%*14/360*1,000,000)	$1944.44
		$1,026,944.44
	Reinvest the proceeds at r (30/360*r*1,026,944.44) until June 16	$1711.57
		$1,028,656.01
June 16	Buy $990,267.13 (=1,000,000-1000-8732.87) FNMA 5% at 102-2	-$1,010,691.39
	Pay 15 days accrued coupon payments to (5%*15/360*990,267.13)	-$2.063.06
		-$1,012,754.45
	Net Proceeds from Rolling as of June 16 (1,028,656.01-1,012754.45)	**$15,901.56**
D: Cash Flow of Rolling vs Holding the MBS		
	15,901.56-13,892.99	**$2,008.57**
E: Dollar Roll Financing Rate		
	Dollar roll implied financing rate=Reinvestment rate at which rolling and holding the MBS are indifferent as of June 16 (Solve for r in 1,026,944.44*(1+r*30/360)-1,012,754.45=13,892.99)	r=**-0.35%**

Note: This table provides the calculation of a dollar roll example. The numbers are hypothetical.

which gives $r = -0.35\%$ in this example. Since the roll seller may receive an inferior MBS in the future-month leg, the negative implied financing rate is not an arbitrage. Rather, it reflects the price of redelivery risk and ownership exchange, as well as other frictions in the market.

B Accounting Treatment of Dollar Rolls and Repos

In general, dollar rolls and repos may be accounted as sales/purchases or financing, depending on whether certain conditions are met, as set by the Financial Accounting Standards Board (FASB) Accounting Standards Codification (ASC) 860. A key condition is whether the transferee (security borrower) returns "substantially the same" security, which gives the transferor (security lender) "effective control" over the security. See EY (2016) for more details.

Because accounting treatment depends on specific circumstances, we investigate the *de facto* treatment of dollar rolls and repos by major players in MBS markets. The evidence suggests that dollar rolls are more likely treated as sales and purchases (off balance sheet), whereas repos are more likely treated as secured financing (on balances sheet). For example:

- Board of Governors of the Federal Reserve System (2017), pages 107–108, states

  > Transfers of MBS upon settlement of the initial TBA MBS transactions are accounted for as purchases or sales in accordance with FASB ASC Topic 860, *Transfers and Servicing*, and the related outstanding commitments are accounted for on a settlement-date basis.
  >
  > ......
  >
  > The tri-party agreements are accounted for as financing transactions ... Securities sold under agreements to repurchase ... are treated as secured borrowing transactions...

- Freddie Mac's response to the SEC in 2011, paragraph 28,[29] states:

  > Freddie Mac has accounted for all dollar roll transactions as purchases and sales during 2009, 2010, and the first half of 2011... The transferee is free to pledge or exchange the security without constraint. Freddie Mac does not maintain effective control over the transferred security through an agreement that entitles and obligates us to repurchase the security before maturity. While we will purchase a security at the end of the dollar roll transaction, our obligation is to purchase a TBA eligible security, a term that is not specific enough to ensure that we will receive the same, or substantially the same, security that was originally transferred. As a result, we believe our dollar roll transactions meet all of the criteria in FASB ASC 86-10-40-5

[29] See https://www.sec.gov/Archives/edgar/data/1026214/000095012311095773/filename1.htm.

(*Transfers and Servicing* > *Overall* > *Derecognition* > *Conditions for Sales of Financial Assets*).

Freddie Mac accounts for all its repurchase and resale agreements as secured financings because the transferor does not relinquish control over the transferred assets.

- KPMG (2011) states that dollar rolls are "generally accounted for as sales under existing guidance" because "the existing collateral maintenance requirements necessary to maintain effective control are not met."

- The 2011 American Institute of CPAs (AICPA) meeting except, page 2-3,[30] states

> Dollar roll accounting— . . . Therefore, in trading situations where only SIFMA Uniform Practices are adhered to and there are no stipulations that would specifically satisfy the substantially-the-same criteria, effective control has been relinquished and purchase and sale accounting would apply.

Recall that our sample period is from July 1998 to July 2013. During this period, the above evidence suggests that dollar rolls are likely treated as sales and purchases (off balance sheet), whereas repos are likely treated as secured financing (on balance sheet).

Toward the end of our sample period, in April 2011, FASB issued ASU 2011-3, *Transfers and Servicing (Topic 860), Reconsideration of Effective Control for Repurchase Agreements*, effective from the first interim or annual period beginning on or after December 15, 2011. This guideline aims to treat more repo-like transactions as secured financing, and dollar rolls are likely impacted. KPMG (2011) states

> Currently entities account for the majority of repo agreements as secured borrowings, not sales, because the transferor maintains effective control over the transferred assets. When the ASU becomes effective, even more repo agreements, such as dollar-roll repo agreements, are likely to be accounted for as secured borrowings.
>
> . . . . . .
>
> Because the obligation to repurchase a transferred MBS is recognized as a repo obligation in a secured borrowing transaction, an investment fund would report increased leverage in its financial statements.

That said, note that Federal Reserve banks continue to treat dollar rolls as sales and purchases to date, according to the above quote from Board of Governors of the Federal Reserve System (2017).

[30] See https://www.aicpa.org/interestareas/frc/industryinsights/downloadabledocuments/inv_ep_minutes/inv_ep_septembe

C A Glossary of Key Regression Variables

Table C1: List of variables used in regressions and their units and definitions

Variable	Unit	Explanation
Specialness_{it}	%	Dollar roll specialness of cohort i in month t, defined as the General Collateral MBS repo rate minus the implied financing rate in dollar rolls, measured one day before the notice day of month t
Disp_{it}^{CPR}	%	Dispersion of realized prepayment rates within coupon cohorts i in month t
Payup_{it}	Cents per \$1 face value	The volume-weighted average price of specified pool price minus the TBA price of cohort i in month t
Trade^{SP}	\$100 million	The trading volume of specified pool of cohort i in month t
Leverage_{t}	Unitless	The ratio of primary dealers' assets over their equity values at the holding company level, then squared, in month t
$\text{CPR}_{it}^{Signed,Change}$	Unitless	Time-series difference of average realized prepayment speed of cohort i, multiplied by -1 if cohort i is in discount
OAS_{it}	Basis points	Option adjusted spread
Ret_{it}^{TBA}	%	Return of rolling TBA month by month and investing the proceeds at risk-free rate
d_{it}^{roll}	Dummy (0/1)	1 if the Fed conducted (net) dollar roll sales in cohort i for settling in month t, and 0 otherwise
$\text{Q}_{it}^{outright}$	\$ billion	The Fed's outright purchase of MBS in cohort i in month t

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Internet Appendix for "Mortgage Dollar Roll"

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In this internet appendix, we present robustness checks and conduct additional analysis on determinants of dollar roll specialness.

1 Robustness Checks

In this section we conduct a number of robustness checks.

First, one could be concerned that our data on specialness depends on the prepayment model of the data provider, J.P. Morgan. Panel A of Table IA1 reports results from the regression on the determinant of specialness, based on historical realized prepayment rates (Specialness^{Hist}), which does not depend on any prepayment model or assumption. The results are similar to the baseline results in the main text of the paper, showing that our findings on the determinants of dollar roll specialness are robust to dealers' prepayment models. Panel B of Table IA1 reports results from the regression on the relation between specialness and expected MBS returns, using the OAS measure from Barclays rather than J.P. Morgan. Similar to the baseline results in the main text of the paper, the coefficient on specialness is negative and highly significant, showing that the negative association between MBS return and dollar roll specialness is also robust to dealers' prepayment models.

Second, to alleviate potential concerns on the sample choice, Panel A of Table IA2 repeats the analysis in Table 6 of the paper with aggressive sample restrictions: we exclude the 2% cohort and restrict the moneyness range to $(-0.75, 2.75)$. Such a moneyness range is smaller and more conservative than those used in other recent studies of MBS, e.g., $[-2.0\%, 3.5\%]$ in Diep, Eisfeldt, and Richardson (2017) and $[-2\%, 4\%]$ in Boyarchenko, Fuster, and Lucca (2015), and only includes cohorts that are actively traded (Panel B reports the summary statistics of this conservative sample). The results are similar to those in Table 6, confirming the robustness of our main results.

Third, Panel A of Table IA3 reports panel regressions of dollar roll specialness on two alternative measures of redelivery risk, $Disp^{CPR,\ 5\%}$ based on the 5/95% percentiles relative to the median and $Disp^{CPR,\ 10\%}$ based on the 10/90% percentiles relative to the median, of

Table IA1: Robustness to Prepayment Models

A: Regression of Specialness^{Hist}				
Disp^{CPR}	0.977***	1.822***	0.664***	1.635***
	(4.720)	(9.517)	(3.171)	(10.297)
Leverage	-0.043***	-0.025**		
	(-3.670)	(-2.533)		
$CPR^{Signed,Change}$	-1.029**	-0.799**	-1.135**	-0.395
	(-2.130)	(-1.966)	(-2.310)	(-1.105)
Constant	-0.501***	-0.277	-0.385	0.134
	(-3.206)	(-0.885)	(-0.715)	(0.280)
N	760	760	760	760
R^2	0.086	0.297	0.335	0.612
Moneyness FE	No	Yes	No	Yes
Time FE	No	No	Yes	Yes
B: OAS Measure from Barclays				
Specialness	-26.393***	-21.910***	-27.840***	-20.463***
	(-16.503)	(-14.106)	(-18.950)	(-13.328)
Constant	27.426***	10.661	15.757	8.002
	(11.192)	(1.195)	(1.207)	(0.563)
N	1,456	1,456	1,456	1,456
R^2	0.366	0.456	0.646	0.700
Moneyness FE	No	Yes	No	Yes
Time FE	No	No	Yes	Yes

Note: Panel A of reports determinants of dollar roll specialness using the measure of specialness based on historical realized prepayment rates (Specialness^{Hist}), whereas Panel B reports results of the relation between dollar roll specialness and expected MBS returns using the OAS measure from Barclays, instead of J.P. Morgan. Robust t-statistics based on panel Newey-West standard errors of Driscoll and Kraay (1998) with the $T^{1/4}$ bandwidth are reported in parentheses. Significance levels: *** for $p < 0.01$, ** for $p < 0.05$, and * for $p < 0.1$, where p is the p-value. The overall sample period is from July 1998 to July 2013.

Table IA2: Robustness to Sample Choice

A: Multiple Variate Regressoin of Dollar Roll Specialness

Variables	(1)	(2)	(3)	(4)	Variables	(5)
Disp^{CPR}	0.754***	0.620***	0.428***	0.981***	$CPR^{forecast}$	3.276***
	(4.935)	(4.693)	(3.482)	(7.712)		(8.173)
Leverage	-0.012	-0.023***			Leverage	-0.030***
	(-1.365)	(-3.411)				(-3.700)
$CPR^{Signed,Change}$	-1.759***	-0.665**	-1.511***	-0.908***		
	(-5.199)	(-2.170)	(-5.164)	(-3.272)		
Constant	-0.235**	0.892***	0.476	0.554**	Constant	1.233***
	(-1.999)	(4.318)	(1.635)	(2.014)		(3.960)
N	570	570	570	570		1,019
R^2	0.138	0.442	0.548	0.612		0.286
Moneyness FE	No	Yes	No	Yes		Yes
Time FE	No	No	Yes	Yes		No

B: Summary of Data Sample and Moneyness

Coupon Rate (%)	Begin	End	N	mean	sd	min	max
3.0	2010/08	2013/07	24	0.24	0.42	-0.58	0.92
3.5	2009/01	2013/07	38	0.34	0.65	-0.69	1.42
4.0	2008/12	2013/07	53	0.49	0.79	-0.70	1.92
4.5	2005/07	2013/07	58	0.85	0.89	-0.70	2.42
5.0	2005/07	2013/07	68	0.92	1.04	-0.73	2.67
5.5	2005/07	2013/07	78	0.78	1.04	-0.69	2.74
6.0	2005/07	2013/07	72	1.00	0.91	-0.38	2.72
6.5	2005/07	2011/07	64	1.32	0.80	0.12	2.73
7.0	2005/08	2011/04	53	1.60	0.67	0.62	2.74
7.5	2005/09	2009/06	38	1.74	0.34	1.12	2.48
8.0	2006/11	2008/11	21	2.21	0.26	1.65	2.74
8.5	2007/10	2008/08	5	2.60	0.10	2.49	2.71

Note: Panel A reports similar results to those in Table 6 of the paper but on a data sample containing cohorts with moneyness within the range of (-0.75%, 2.75%). Panel B reports the beginning month, ending month, and number of monthly observations, as well as the mean, standard deviation (sd), minimum, and maximum of the moneyness (all in percentage points) for the monthly series of dollar roll contracts included.

the prepayment rates across MBS in a cohort. Panel B of Table IA3 reports panel regressions of dollar roll specialness on an alternative measure of ΔCPR using the difference between the realized prepayment rate at month t and the realized prepayment rate at month $t-1$. We observe that the results are significant and robust with all these alternative measures.

Fourth, Table IA4 reports panel regressions of specialness on $Disp_{it}^{CPR}$, $Leverage_t$, and $CPR_{it}^{Signed,Change}$ as well as panel regressions of OAS on specialness, controlling for coupon fixed effects. The results are roughly similar to the baseline results using moneyness fixed effects.

2 Counterparty Risk

Given that the dollar roll contract spans a period of at least a month, the default of a counterparty during the financing period is not zero. Default risks can usually be mitigated (if not eliminated) by charging margin. However, only very recently did regulators recommend and impose margin requirements in the TBA market. In particular, the Treasury Market Practices Group (TMPG) recommended margining of TBA trades for the first time in November 2012 and expected the process to be complete by December 2013.[1] Informed by this recommendation of the TMPG, in October 2015 FINRA filed with the Securities and Exchange Commission (SEC) a proposed amendment to FINRA Rule 4210 to establish margin requirements for transactions in the TBA market. Therefore, there was no mandatory margining on dollar roll trades in our sample period. The usual market practice is that margin is posted in the TBA trades between members of the Mortgage-Backed Securities Division of the Fixed-Income Clearing Corporation, while much less so in bilateral dealer-customer trades (TMPG (2012)). We hence expect credit risk to have some effect on implied dollar roll financing rates. In particular, as our implied financing rate (IFR) data come from J.P. Morgan, a dealer, and because dealers are usually dollar roll buyers, we expect the credit risk of J.P. Morgan to negatively affect the IFR because J.P. Morgan's default risk could prompt roll sellers to demand a favorable (low) financing rate. That said, roll buyers' credit risk may not have any significant effect on dollar roll specialness because GC repo rates should be affected by credit risk in a similar fashion as dollar roll financing rates are.

To investigate how credit risk affects dollar roll financing rates and specialness, we obtain the 5-year senior unsecured CDS spread on J.P. Morgan from Markit as a proxy for its credit risk. The CDS spread is a daily time series available from July 2004 to July 2013. We construct monthly CDS spread in a matter similar to the construction of IFR.

[1]The TMPG is composed of a group of market professionals from securities dealers, banks, and buy-side firms, and commits to supporting the integrity and efficiency of the U.S. Treasury market. Sponsored by the Federal Reserve Bank of New York, they meet periodically to discuss trading issues in Treasury, agency debt, and agency MBS markets.

Table IA3: Alternative Measures of Redelivery Risk and Prepayment Transfer

A: Alternative Measures of Redelivery Risk				
	Disp=Disp$^{CPR,\ 5\%}$			
Disp	0.076***	0.077***	0.073***	0.025**
	(6.380)	(7.802)	(5.650)	(2.193)
Constant	0.310***	1.144***	0.107	1.618***
	(3.143)	(3.136)	(0.303)	(3.787)
N	762	762	762	762
R^2	0.098	0.444	0.158	0.556
Moneyness FE	No	No	Yes	Yes
Time FE	No	Yes	No	Yes
	Disp=Disp$^{CPR,\ 10\%}$			
Disp	0.098***	0.103***	0.088***	0.029**
	(5.957)	(7.556)	(5.084)	(2.022)
Constant	0.252***	1.108***	0.108	1.652***
	(2.630)	(3.014)	(0.302)	(3.878)
N	762	762	762	762
R^2	0.080	0.434	0.141	0.554
Moneyness FE	No	No	Yes	Yes
Time FE	No	Yes	No	Yes
B: Altenative Measures of Prepayment Exposure Transfer				
$CPR_{it}^{Signed,Change}$	-1.277***	-1.286***	-0.860**	-0.972***
	(-3.072)	(-3.222)	(-2.179)	(-2.851)
Constant	-0.071	0.104	0.691*	1.709***
	(-0.846)	(0.280)	(1.800)	(4.030)
N	750	750	750	750
R^2	0.008	0.100	0.371	0.559
Moneyness FE	No	Yes	No	Yes
Time FE	No	No	Yes	Yes

Note: Panel A reports panel regressions of dollar roll specialness on two alternative measures of redelivery risk, $Disp^{CPR,\ 5\%}$ based on the 5/95% percentiles relative to the median and $Disp^{CPR,\ 10\%}$ based on the 10/90% percentiles relative to the median, of the prepayment rates across MBS in a cohort. Panel B reports panel regressions of dollar roll specialness on the alternative measure of prepayment exposure transfer constructed based on the difference between the realized prepayment rate at month t and the realized prepayment rate at month $t-1$. Robust t-statistics based on panel Newey-West standard errors of Driscoll and Kraay (1998) with the $T^{1/4}$ bandwidth are reported in parentheses. Significance levels: ** for $p < 0.01$, * for $p < 0.05$, and $^{+}$ for $p < 0.1$, where p is the p-value.

Table IA4: Control for Coupon Fixed Effects

Variables	Specialness	Specialness	Specialness	OAS	OAS
Disp^{CPR}	0.673***	-0.002			
	(3.027)	(-0.008)			
Leverage	-0.041***		-0.060***		
	(-3.744)		(-5.944)		
$CPR^{Signed,Change}$	-1.324***	-0.615			
	(-2.741)	(-1.252)			
$CPR^{forecast}$			3.113***		
			(6.983)		
Specialness				-17.290***	-16.363***
				(-14.428)	(-15.464)
Constant	-3.949***	-3.131***	-2.071***	49.970	13.647
	(-8.189)	(-5.191)	(-8.453)	(1.443)	(0.461)
N	760	760	1,293	1,409	1,409
R^2	0.276	0.552	0.209	0.294	0.647
Coupon FE	Yes	Yes	Yes	Yes	Yes
Time FE	No	Yes	No	No	Yes

Note: The first three columns report panel regressions on determinants of dollar roll specialness, whereas the last two columns report panel regressions of option-adjusted spreads on dollar roll specialness. Robust t-statistics based on panel Newey-West standard errors of Driscoll and Kraay (1998) with the $T^{1/4}$ bandwidth are reported in parentheses. Significance levels: ** for $p < 0.01$, * for $p < 0.05$, and $^{+}$ for $p < 0.1$, where p is the p-value.

Panel A of Table IA5 reports panel regressions based on

$$Y_{it} = \sum_i \gamma_i D_i + \beta \cdot JPM_t^{cds} + \epsilon_{it}, \tag{1}$$

where Y_{it} is IFR_{it} or $Specialness_{it}$. Note that we do not include time dummies as JPM_t^{cds} is a pure time-series variable.[2] Results in the first two columns of Panel A show that JPM_t^{cds} has a significantly negative impact on IFRs, confirming that credit risk is an important determinant of dollar roll financing rates. Results in the last two columns show that specialness is significantly affected by credit risk only when moneyness dummies are included.

3 Settlement Failure

In practice, the security borrower in a dollar roll transaction may delay the redelivery of MBS to the roll seller in the future-month TBA contract. In this case, we say the roll is "trading at fail." Fails could happen if there is a temporary shortage of MBS that satisfy the TBA delivery requirements due to, for example, a high volume of CMO deals. In the case of trading at fail, the dollar roll seller benefits by not having to pay the cash back to the security borrower until the MBS is delivered back. At the same time, the roll seller is still entitled to the principal and coupon payments of the MBS that the roll buyer fails to return. That is, while the dollar roll is trading at fail, the roll seller effectively borrows from the roll buyer at the 0% financing rate. Without a penalty on failure to deliver, a sufficiently negative implied financing rate in a dollar roll trade can encourage the MBS borrower in the roll transaction to fail strategically and charge a more desirable 0% financing rate, instead of the negative financing rate implied by the dollar roll.[3] Therefore, we expect the amount of failure to deliver to be negatively associated with the IFR. On the other hand, we expect the amount of delivery failures to have no significant effect on dollar roll specialness. This is because GC repo rates should be affected by failure to deliver in a similar fashion as dollar roll financing rates are.

We obtain the amount of delivery fails in agency MBS transactions by U.S. Primary Dealers from the web site of the Federal Reserve Bank of New York.[4] The failure-to-deliver data

[2] We find similar results when controlling for year or quarter fixed effects.

[3] Assuming that the returned MBS is the same as the original one, this strategic incentive would bound the dollar roll financing rate at 0% from below. However, given the redelivery risk in a dollar roll transaction, the implied financing rate can fall below 0% significantly, as a compensation to the roll seller. This suggests that some security borrowers (roll buyers) view returning an MBS with inferior prepayment characteristics in the future-month TBA contract to be more advantageous than invoking a fail and holding onto the MBS. This usually happens when primary mortgage rate falls and new MBS issuance moves to lower coupon brackets, in which case holders of MBS with immediately higher coupons are subject to high prepayment risk and are better off delivering them. Reputation concerns may also prevent the security borrowers to fail excessively.

[4] See Fleming and Garbade (2005) for detailed explanations of the settlement fails data.

Table IA5: Credit Risk and Settlement Fails

	A: Credit Risk			
	IFR	IFR	Specialness	Specialness
JPM^{cds}	-0.035***	-0.035***	0.002	0.005***
	(-13.964)	(-13.805)	(1.455)	(3.453)
Constant	4.686***	5.229***	-0.246*	-0.031
	(20.286)	(9.398)	(-1.733)	(-0.094)
N	786	786	786	786
R^2	0.340	0.349	0.005	0.119
Moneyness FE	No	Yes	No	Yes
	B: Settlement Fails			
	IFR	IFR	Specialness	Specialness
Fail (All Sample)	-6.1988**		1.5585**	
	(-8.8912)		(4.9458)	
Fail (Sample with Fails Charge)		-0.3342		0.2894
		(-0.4907)		(0.4638)
Constant	4.5344**	-0.6780**	-0.0100	0.9661**
	(14.1671)	(-2.8482)	(-0.1139)	(4.0724)
N	752	100	752	100
R^2	0.2897	0.3395	0.1753	0.3432
Moneyness FE	Yes	Yes	Yes	Yes

Note: Panel A regresses IFR_{it} or $Specialness_{it}$ on the credit default swap spread of J.P. Morgan. Panel B regresses IFR_{it} or $Specialness_{it}$ on settlement failure, where the first row uses the full sample and the second row restricts the sample to after February 2012 after fails charge is imposed. Robust t-statistics based on panel Newey-West standard errors of Driscoll and Kraay (1998) with the $T^{1/4}$ bandwidth are reported in parentheses. Significance levels: *** for $p < 0.01$, ** for $p < 0.05$, and * for $p < 0.1$, where p is the p-value. The overall sample period is July 1998 to July 2013, with various starting dates that depend on coupon rates.

are at the weekly frequency from January 2003 to July 2013, and we construct monthly time series taking the first week of each month. Panels B of Table IA5 reports panel regressions based on

$$Y_{it} = \sum_i \gamma_i D_i + \beta \cdot Fail_t + \epsilon_{it}, \tag{2}$$

respectively, where Y_{it} is IFR_{it} or $Specialness_{it}$. Note that we do not include time dummies as $Fail_t$ is a pure time-series variable. In the full sample (first row), we observe that a larger volume of settlement fails is associated with statistically significant lower dollar roll financing rates and higher specialness.

A fails charge of 2% for agency MBS markets began on February 1, 2012, as proposed by the TMPG (a fails charge for transactions in U.S. Treasury securities has been imposed since May 1, 2009). To test whether this important regulatory event affects the relation between settlement fails and IFRs, we run regression in (2) with the post-February 2012 subsample. The second row of Panel B shows that neither IFR nor specialness is related to fail-to-deliver volume in this subsample. Besides lower power of tests in a smaller sample, another potential reason for the statistical insignificance on IFR is that the 2% charge roughly compensates market participants for the risk that their counterparties may fail to deliver.

4 Interest Rate Volatility and MBS Collateral Value

In this section we consider two additional measures motivated from the Treasury market. The first measure is the volatilities of the level and the slope of the interest rate term structure. The second is the general collateral repo rate of agency MBS minus that of Treasury securities.

The motivation for the first measure (interest rate volatility) is that both the Treasury futures market and dollar rolls involve delivery options. The value of delivery option in Treasury futures naturally depends on the volatilities of the level and the slope of the interest rate term structure.[5] Therefore, we use the contemporaneous implied volatility of at-the-money 1-year-by-10-year swaption, denoted IV^{10y}, as a proxy for the volatility of the level factor, and use the trailing 30-day realized volatility of the 10-year-versus-2-year swap rates, denoted RV^{10y-2y}, as a proxy for the volatility of the slope factor, both obtained from Barclays.

We should stress that these volatilities may be related to more than one aspect of dollar rolls. The delivery options channel suggests that dollar roll specialness should be higher in volatile times. On the other hand, a higher volatility of interest rate (level) may also change the risk preference of major participants in MBS markets. In volatile times, to the extent that these players become more risk-averse, the possibility of obtaining balance sheet relief by selling into dollar rolls suggests that dollar roll specialness should be lower in such times. Therefore, the same volatility change has ambiguous implication on dollar rolls specialness because delivery risk and ownership exchange operate in opposite directions. Which way dominates is an empirical question.

[5] See, for example, Margrabe (1978) and Gay and Manaster (1984). Following the main idea of these papers, we provide an informal argument. For simplicity, consider the case with two deliverable Treasury bonds into the futures contract, one with maturity n years and the other with maturity m years. One can show that the option of exchanging one Treasury bond for another is related to the volatility of $\log(P_n/P_m)$, where the P's are the prices of these bonds. If the two bonds are zero-coupon with yield y_n and y_m, then $\log(P_n/P_m)] = -ny_n + my_m = (m-n)y_n + m(y_m - y_n)]$. To the extent that y_n is dominated by the level factor of the yield curve and $y_m - y_n$ is dominated by the slope factor, the value of the exchange option is naturally related to the volatilities of the level factor and the slope factor. The covariance between y_n and $y_m - y_n$ is generally small because the level and slope factors are orthogonal, by construction.

Table IA6: Interest Rate Volatility and MBS-Treasury Repo Spread

	(1)	(2)	(3)	(4)	(5)	(6)
Disp^{CPR}					0.766***	1.606***
					(3.768)	(8.068)
Leverage					-0.011	-0.001
					(-0.962)	(-0.085)
$CPR^{Signed,Change}$					-1.850***	-1.703***
					(-3.883)	(-3.922)
IV^{10y}	-0.013***	-0.012***			-0.018***	-0.015***
	(-4.058)	(-3.890)			(-5.219)	(-5.169)
RV^{10y-2y}	-0.318*	-0.439**			0.033	-0.131
	(-1.677)	(-2.428)			(0.190)	(-0.848)
$\text{GCFRepo}^{MBS-Tsy}$			-1.926**	-2.611***	-1.033	-1.790***
			(-2.233)	(-3.192)	(-1.343)	(-2.613)
Constant	1.363***	1.326***	0.020	0.321	1.243***	1.277***
	(3.805)	(2.841)	(0.218)	(0.876)	(3.332)	(3.119)
N	762	762	762	762	760	760
R^2	0.049	0.136	0.011	0.113	0.209	0.334
Moneyness FE	No	Yes	No	Yes	No	Yes

Note: This table reports panel regressions of dollar roll specialness on the implied volatility of at-the-money 1-year-by-10-year swaption (IV^{10y}), the realized volatility of the 10-year-versus-2-year swap rate (RV^{10y-2y}), and the repo rate spread between general collateral agency MBS repo and Treasury repo ($GCFRepo^{MBS-Tsy}$). Robust t-statistics based on panel Newey-West standard errors of Driscoll and Kraay (1998) with the $T^{1/4}$ bandwidth are reported in parentheses. Significance levels: *** for $p < 0.01$, ** for $p < 0.05$, and * for $p < 0.1$, where p is the p-value. The overall sample period is from July 1998 to July 2013.

The motivation for the MBS-Treasury repo rate spread, denoted $GCFRepo^{MBS-Tsy}$ and measured contemporaneously, is that a higher spread of repo rates could indicate concern or uncertainty about the underlying value of agency MBS, which in turn suggests unfavorable or volatile prepayment speed. In this situation MBS investors may prefer selling into dollar rolls to avoid the prepayment risk exposure, relative to financing them by repo, suggesting a lower dollar roll specialness. On the other hand, to the extent that unfavorable or volatile prepayment speed also increases dispersion of prepayment rates within the same coupon cohort, the redelivery risk channel would suggest a higher dollar roll specialness. Thus, the repo spread is also potentially related to multiple aspects of dollar rolls and has ambiguous implications on dollar roll specialness.

Table IA6 reports panel regressions of dollar roll specialness on IV^{10y}, RV^{10y-2y}, and

$GCFRepo^{MBS-Tsy}$. Since these variables are purely time series, we do not include time fixed effects but add moneyness fixed effect in some specifications. We observe that dollar roll specialness loads negatively on IV^{10y} and RV^{10y-2y}, suggesting that the effect of higher risk aversion in volatile times dominates that of more valuable delivery option. The coefficient on $GCFRepo^{MBS-Tsy}$ is significantly negative, consistent with the channel of prepayment risk transfer of dollar rolls.

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