Mortgage Dollar Roll *

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Abstract

The most important financing strategy of agency MBS – mortgage dollar roll – is a secured lending contract with the unique feature that returned MBS collateral can differ from those received, creating adverse selection for the cash borrower. Using a proprietary dataset, we provide the first analysis of dollar roll "specialness", the extent to which implied dollar roll financing rates fall below prevailing market rates. Dollar roll specialness increases in adverse selection and decreases in MBS liquidity. Specialness is also negatively related to expected MBS returns. Moreover, the Federal Reserve's MBS purchases and dollar roll sales are associated with lower specialness.

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1 Introduction

*"The Federal Reserve Bank of New York on Tuesday said it has been conducting a type of mortgage-bond-repurchase transaction to aid the earlier settlement of its outstanding mortgage-backed securities purchases, which is supporting the larger market. In purchasing the **dollar rolls**, the Fed could be relieving liquidity bottlenecks for investors who need to borrow a security they are short but have contracted to deliver to a buyer..."*

—The Wall Street Journal, December 6, 2011

This paper provides an empirical analysis of the funding market of agency mortgage-backed-securities (MBS). A better understanding of this market is important because of its large size and its tight connection to the implementation of unconventional monetary policy in the United States, as we elaborate below. Analyzing the MBS funding market also provides unique economic insights that are absent in the repo markets of fixed-income securities.

Agency 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] According to SIFMA, as of the third quarter of 2015, the outstanding amount of agency MBS is about \$7.14 trillion, which is more than a half of the outstanding \$12.84 trillion of U.S. Treasury securities. The average daily trading volume of agency MBS is 20 times larger than that of corporate bonds, and close to 60% of that for Treasury securities in 2010, according to Vickery and Wright (2011).

Besides its large size and trading volume, the agency MBS market also plays a prominent role in the implementation of U.S. monetary policy since the global financial crisis. The Federal Reserve 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. Furthermore, the Federal Open Market Committee has announced in its September 2014 statement that the Federal Reserve will continue to use its MBS holdings to conduct reverse

[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.

repo transactions as a regular policy tool in the future (see Frost, Logan, Martin, McCabe, Natalucci, and Remache (2015)).

About a half of the trading volume in the entire agency MBS market is conducted through a type of strategy called (mortgage) "dollar roll", the most widely used mechanism by which investors finance their positions in agency MBS and hedge their existing MBS exposures (Gao, Schultz, and Song (2015)). It is also a particularly important tool that the Federal Reserve uses actively in its operations of quantitative easing (see the Wall Street Journal quote above). Specifically, a mortgage dollar roll is the combination of two forward contracts on MBS, one front month and one future month. These forward contracts are traded in the liquid "to-be-announced" (TBA) market, which comprises over 90% of agency MBS trading volume and all the Federal Reserve's MBS purchases. In a dollar roll transaction the "roll seller" sells an MBS in the front-month TBA contract and simultaneously buys an MBS in the future-month TBA contract, both at specified prices. A roll buyer does the opposite.

A unique feature of the TBA market is that, on the trade date, the two counterparties only agree on generic security characteristics, such as agency, coupon, and original mortgage term, but not the specific CUSIPs to be delivered. A dollar roll, as a combination of two TBA trades, inherits this important feature. For example, a particular dollar roll contract may specify that the deliverable MBS must be guaranteed by Fannie Mae, with the original loan term of 30 years and a coupon rate of 4% per year. But on the trade date it does not specify the particular CUSIP of MBS to be delivered. Thus, the short side has a strong incentive to deliver the cheapest CUSIP that satisfy these parameters, creating adverse selection for the long side. In particular, after the roll seller delivers an MBS in the front month of a dollar roll, he may (and is likely to) receive a different, potentially inferior MBS in the future month.[3] This adverse-selection risk is reflected by the prices in the two legs of the dollar roll.

It is convenient and intuitive to view a dollar roll as a collateralized borrowing contract, with the roll seller being the cash borrower. Compared to a standard repo contract, however, the roll seller faces a substantial risk that the collateral redelivered at the end of the contract are inferior to the original collateral lent out. To compensate for this risk, the roll seller, equivalently the cash borrower, pays a low and sometimes even negative implied financing

[3]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 3 and Section 4 for detailed discussions.

rate. A dollar roll is said to be "on special" if this implied financing rate is lower than the prevailing market interest rate, such as the general-collateral (GC) repo rate on the MBS or unsecured rates like LIBOR. The specialness of a dollar roll is hence a key indicator of funding conditions in agency MBS markets, just as repo specialness is a key indicator of funding conditions in U.S. Treasury markets.

To the best of our knowledge, this paper provides the first analysis of the economics of dollar roll specialness. We ask the following three questions:

1. What economic forces determine dollar roll specialness?
2. What is the relation between dollar roll specialness and the expected MBS returns?
3. How does the Federal Reserve's large-scale asset purchase of agency MBS affect dollar roll specialness, and through which channels?

Answers to these questions would shed light on this important yet underexplored market in the academic literature. It also provides new evidence on the effect of unconventional monetary policy on market functioning.

Our analysis starts with an analytic framework that encompasses two important determinants of dollar roll specialness. The first is associated with the key feature of a dollar roll transaction: securities changing hands in the two legs of a dollar roll need not be the same, but only "substantially similar," as defined by a set of parameters.[4] We call the collection of MBS CUSIPs that satisfy a particular set of parameters a "cohort." Therefore, the roll buyer can potentially (and generally will) deliver the cheapest MBS within a cohort to the roll seller (the cheapest-to-deliver (CTD) option). An agency MBS is cheap mainly because it has inferior prepayment characteristics not specified in the TBA contract, such as the loan-to-value ratio, FICO score, past prepayment behavior, and location of the mortgage, relative to other agency MBS in the same cohort.[5] (The default risk is insured by the agencies.) This adverse selection lowers the interest rate that the roll seller is willing to pay and hence increases specialness. We illustrate the adverse-selection channel in a simple and stylized model.

[4]The criterion of "substantially similar" is defined in the American Institute of Certified Public Accountants State of Position 90-3 such that the original and returned MBS should be of the same agency, original loan term, and coupon rate, and both should satisfy Good Delivery requirement set by SIFMA.

[5]We emphasize that inferior prepayment characteristics do not necessarily mean higher prepayment speeds. A high prepayment speed usually implies a low value for a premium MBS with value above par, but a high value for a discount MBS with value below par (See Section 3 for details). Hence, MBS with inferior prepayment characteristics refer to those with high (low) prepayment speeds if the corresponding TBA cohort is at premium (discount).

The second determinant of dollar roll specialness is a liquidity channel associated with search frictions, motivated from the literature on over-the-counter markets.[6] Specifically, if MBS supply for dollar roll trading is scarce, it is more costly for roll buyers to locate these MBS due to search frictions. Roll sellers who hold the scarce MBS would be in a more advantageous bargaining position than roll buyers. Hence, the buyer has to offer lower financing rates, which will lead to a higher specialness.

Based on this analytic framework, we empirically study dollar roll specialness using two proprietary data sets. The first data set includes the dollar roll financing rates, option-adjusted spreads, and single-month mortality rates of FNMA 30-year TBA contracts with twelve coupon rates ranging from 3% to 8.5% at the daily frequency over July 2000 – July 2013, provided by J.P. Morgan. We calculate dollar roll specialness as the difference between prevailing one-month interest rates, such as the 1-month general collateral repo rate of agency MBS or the 1-month LIBOR, and the dollar roll financing rates. From these daily time series we construct monthly series of specialness and other variables. The second data set includes the characteristics data of all FNMA 30-year MBS CUSIPs at the monthly frequency over July 2005 – July 2013, provided by eMBS.

Our empirical investigation consists of three parts, corresponding to the three questions above.

Determinants of dollar roll specialness. Our analytic framework reveals two important determinants of dollar roll specialness: adverse selection and liquidity. Our simple model suggests that the adverse-selection channel is closely linked to the expected cohort-level prepayment speed: a higher prepayment speed will lead to a larger heterogeneity of MBS values within the TBA cohort and hence a lower value of the cheapest-to-deliver (CTD) MBS relative to the original collateral. We measure the cohort-level prepayment speed by the widely-used single monthly mortality rate (SMM) (see Hayre (2001)). Our analytic framework also suggests that dollar roll specialness should decrease in the liquidity of MBS market. We proxy liquidity by constructing a measure of the net supply of CTD MBS CUSIPs, labeled $NSupply^{CTD}$. Specifically, starting from the universe of all CUSIPs of a coupon cohort, we eliminate CUSIPs whose characteristics make prepayment unlikely (using criteria similar to those used by Himmelberg, Young, Shan, and Henson (2013)), and then

[6] This liquidity channel is consistent with search theories of Duffie, Garleanu, and Pedersen (2002) and Vayanos and Weill (2008) as well as evidence regarding repo specials and on-the-run premium in Treasury markets (see Jordan and Jordan (1997), Krishnamurthy (2002), and Graveline and McBrady (2011), among others).

sum up the outstanding amount of remaining CUSIPs to construct a raw measure of the supply of CTD cohort. Then we deduct the deal volume of collateralized mortgage obligations (CMOs) from the raw supply measure to get a measure of net supply of CTD cohort.[7]

We test how adverse selection and liquidity affect dollar roll specialness in panel regressions. Confirming the predictions from our analytic framework, a higher prepayment speed (SMM) is associated with higher specialness, and a higher CTD supply ($NSupply^{CTD}$) is associated with a lower specialness. The economic magnitudes are also large. In particular, a one standard deviation increase in SMM increases dollar roll specialness by about 20 basis points, whereas a one standard deviation increase in $NSupply^{CTD}$ decreases specialness by 18 basis points. The significance of these variables is robust to alternative model specifications.[8]

Dollar roll specialness and expected MBS returns. Because a higher specialness implies a lower financing cost, we expect that owners of MBS that are on special are willing to accept lower expected returns from these MBS. That is, we expect a negative specialness-expected return relation. Following Gabaix, Krishnamurthy, and Vigneron (2007), we use the option-adjusted spreads (OAS) as a proxy for expected MBS returns. The OAS is the yield on an MBS in excess of the term structure of interest rates after adjusting for the expected value of homeowners' prepayment options, conditional on the interest rate path.

Using monthly OAS for the same collection of FNMA 30-year TBA contracts, we find a pronounced negative relation between OAS and dollar roll specialness. In particular, an MBS cohort that is on special has an OAS that is about 60 basis points lower than that of an MBS cohort not on special, controlling for coupon and time fixed effects. A one percentage point increase in specialness is associated with an OAS that is about 45 basis points lower. As a robustness check, we use the the realized returns of rolling TBA contracts as an alternative proxy for expected MBS returns, and also find a strong negative relation between specialness and expected MBS returns. These results are robust to a variety of empirical specifications.

The effect of LSAP on dollar roll specialness. As one of the most important central bank actions since the 2008 financial crisis, the large MBS purchase by the Fed raises potential concerns of market distortion. As highlighted by Bernanke (2012), "Conceivably, if the

[7]We are grateful to John Miller for suggesting the agency CMO data on Bloomberg.

[8]These specifications include whether the GC repo rate or LIBOR is used to measure specialness and whether the activeness of the TBA coupon buckets is adjusted. We also obtained similar results using the Barclays data of dollar roll financing rates.

Federal Reserve became too dominant a buyer in certain segments of these markets, trading among private agents could dry up, degrading liquidity and price discovery."

We find that regressing dollar roll specialness on Fed purchases leads to a negative coefficient. While this negative relation suggests that the large size of MBS absorbed by the Fed does not result in (detectable) market distortions, we cautiously interpret it as correlation, rather than causality, because we do not have an exogenous shock to LSAP. That said, we conduct two empirical tests that provide suggestive evidence on how the Fed's transactions in MBS markets may affect specialness. First, the inclusion of SMM and $NSupply^{CTD}$ in the specialness-LSAP regression reduces the magnitude of the negative coefficient on LSAP, suggesting that Fed purchases do interact with adverse selection and supply channels in MBS markets. Second, we find that the Fed conducts more dollar roll sales in coupon cohorts with higher LSAP purchases and lower specialness, suggesting that the Fed attempts to alleviate (real or perceived) squeezes in MBS market by delaying taking delivery of the purchased MBS.

Relation to the literature. To the best our knowledge, this paper is the first academic study of dollar roll specialness. It contributes to three branches of literature: MBS markets, repo specialness, and the effects of the Federal Reserve's asset purchases.

The prior literature on MBS market has predominantly focused on the pricing of MBS. We focus on the financing of MBS. (This difference is analogous to the difference between the pricing of Treasury securities and the financing of them through repo transactions.) Studies on the pricing of MBS include 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, Gabaix, Krishnamurthy, and Vigneron (2007), Duarte, Longstaff, and Yu (2007), Chernov, Dunn, and Longstaff (2015), and Boyarchenko, Fuster, and Lucca (2015) investigate the return patterns of MBS, but they do not connect these return patterns to dollar roll specialness or systematically analyze the determinants of specialness.[9] A recent expanding literature studies the market structure and liquidity of the agency MBS market, including Atanasov and Merrick (2012), Atanasov, Merrick, and Schuster (2014), Bessembinder, Maxwell, and Venkataraman (2013), Downing, Jaffee, and Wallace (2009), Friewald, Jankowitsch, and Subrahmanyam (2014), Gao, Schultz, and Song (2015), and Hollifield, Neklyudov, and Spatt (2014).[10] Dollar roll specialness is not the focus

[9]Two other recent studies, Malkhozov, Mueller, Vedolin, and Venter (2013) and Hansen (2014), show that variables capturing the mortgage risk hedging have return predictive power for Treasury bonds.

[10]After our paper has been widely distributed in January 2014, a very recent paper Kitsul and Ochoa

of any of these studies.

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 Graveline (2013), among others. The economics of dollar roll specialness in agency MBS markets differs substantially from that of Treasury repo specialness in that a dollar roll involves a major adverse-selection risk that an inferior security is returned. Adverse selection is a key determinant of dollar roll specialness.

Lastly, our analysis of the impact of LSAP on dollar roll specialness relates to Hancock and Passmore (2011), Gagnon, Raskin, Remanche, and Sack (2011), Krishnamurthy and Vissing-Jorgensen (2011), Krishnamurthy and Vissing-Jorgensen (2013), and Stroebel and Taylor (2012), who analyze the effect of LSAP on mortgage rates. Among these, Krishnamurthy and Vissing-Jorgensen (2013) highlight the importance of the cheapest-to-deliver option in TBA markets. Complementary to these studies that focus on the *level* of mortgage rates, we investigate the impact of LSAP on MBS funding markets. Kandrac (2013) finds that LSAP is associated with a lower dollar roll implied financing rates, which is also about the *level* of (collateralized) interest rate. He neither studies the determinants of dollar roll specialness nor link the two channels of specialness to LSAP. Our analysis fills this important gap.

2 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).[11] A worked-out example for the computation of dollar roll financing rates are provided in Appendix.

(2014) conducted some similar analyses.

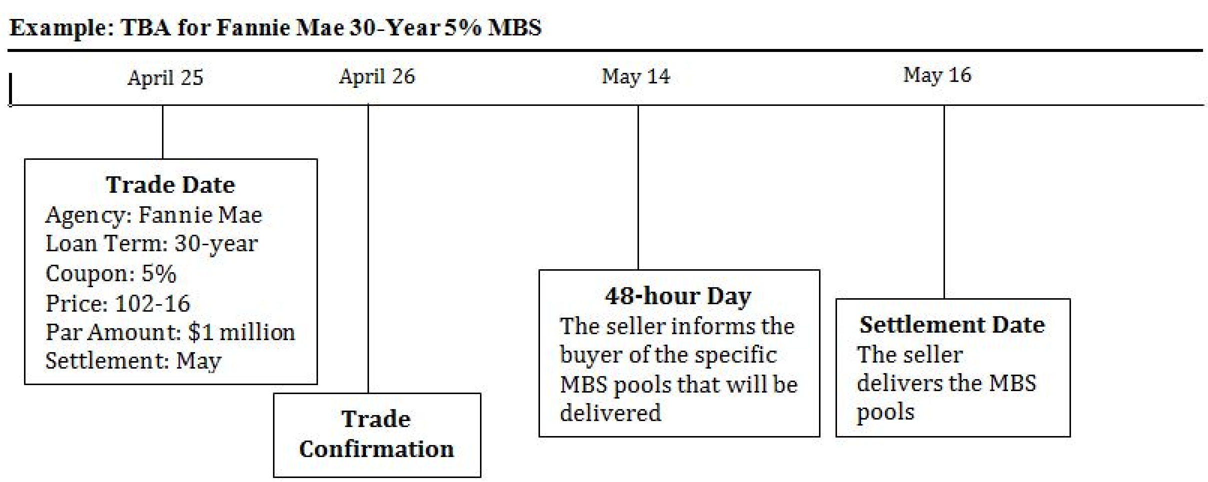
[11] All TBA-eligible MBS are so-called "pass-through" securities, which pass through the monthly principal and interest payments less a service fee from a pool of mortgage loans to owners of the MBS. Structured mortgage-backed-securities like CMOs, which tranche mortgage cash flows with various prepayment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

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.

Figure 1: A TBA Example



Notes: This TBA trade is hypothetical.

- 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.
- 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 (2015)).

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.

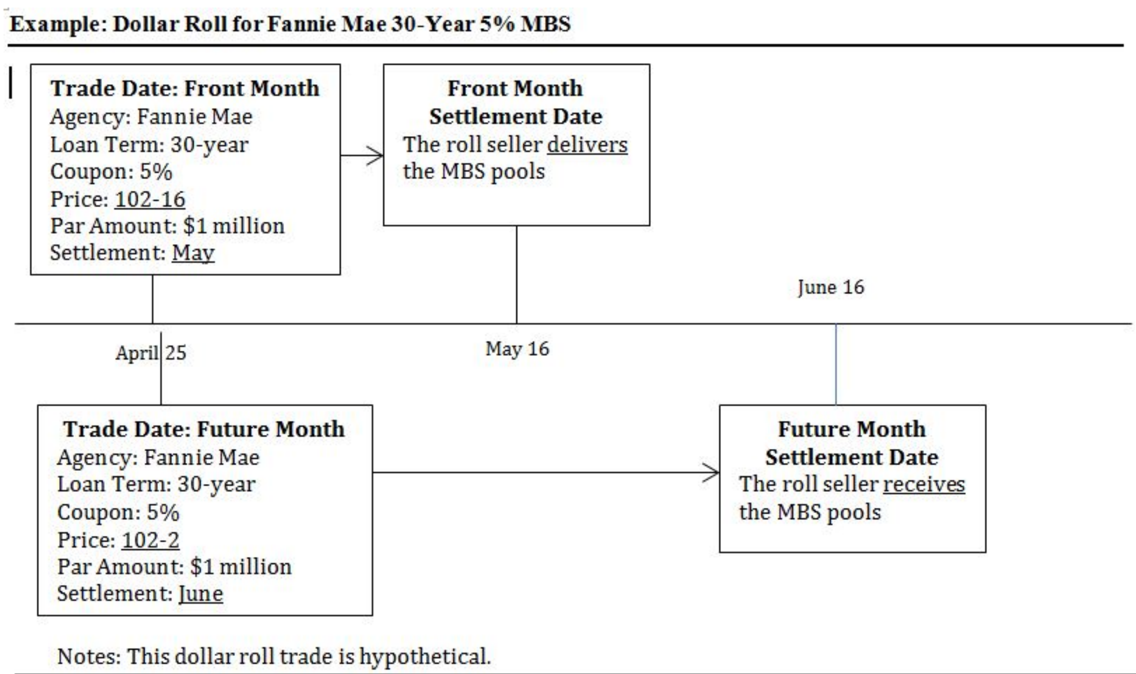
2.2 Dollar roll

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.

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, and most importantly, 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 features, especially the redelivery uncertainty of the returned MBS pool in the future-month leg, differentiates 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.[12]

Figure 2: A Dollar Roll Example



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

[12] 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.

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 dollar roll specialness is provided in the Appendix.

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.[13] Mortgage servicers and money managers are main providers of dollar rolls, with the former enhancing their portfolios returns at desirable financing rates and the latter financing their MBS positions to hedge their interest rate exposure of the loans they service on their books. Hedge funds demand or supply dollar rolls for both hedging and speculation.

2.3 Dollar roll specialness

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 or LIBOR. The specialness of a dollar roll, defined as the market prevailing borrowing 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, as the dollar roll seller bears the redelivery risk, i.e., the risk of an MBS with inferior prepayment characteristics being returned in the future-month TBA contract. The higher is the risk, the lower price the roll seller is willing to offer in the future month of the dollar roll, and the lower is the implied financing rate (see equation (1) and the example in the previous subsection). Hence, specialness is higher. In other words, a positive dollar roll specialness is a compensation for the roll seller for taking the redelivery risk.

To see the intuition more clearly, we consider this stylized example. Suppose that the implied dollar roll financing rate on an MBS (and other MBS in the same cohort) is -1%,

[13]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.

but the repo rate of using this specific MBS for secured borrowing is 2%. An investor with \$1 million cash can engage in the following trades. She lends the cash against the MBS in the repo market for one month at 2%, and subsequently rolling the MBS collateral for one month at the financing rate of -1%. If, by any chance, the same MBS is returned to the investor in the dollar roll market, she can return the same MBS to the repo counterparty and close the repo contract; this earns her the net profit of \$(2%+1%)/12 million. If, however, a different and cheaper MBS is returned in the dollar roll contract, this different MBS cannot be used to close the repo contract, and she must buy or borrow the original MBS to close the repo contract. In this process, she must make up for the price difference between the original MBS and cheaper MBS delivered back in the dollar roll. The specialness of 3% (relative to MBS repo rate), therefore, compensates for such risks borne by the roll seller.

In addition to being a compensation for adverse selection stemming from redelivery risk, dollar roll specialness also reflects the general supply and demand conditions in the TBA market. For example, if the MBS of particular characteristics are scarce in the market, a holder of such MBS can extract more rents in the repo market and security lending market. By rolling this MBS, the roll seller gives up not only the interest and principal payments, but also the rents associated with cheaper financing rates and lending fees. Therefore, the equilibrium implied financing rate in the dollar roll must fall, leading to a higher specialness. The scarcity of a particular class of MBS can be driven by the shorting and hedging activities of dealers and originators, as well as the amounts of newly issued MBS.

3 The Economics of Dollar Roll Specialness

In this section we develop an analytic framework to study the economics of dollar roll specialness. We consider first the determinant of dollar roll specialness and then the relation between dollar roll specialness and expected MBS returns.

3.1 The determinants of dollar roll specialness

In this subsection we focus on two determinants of dollar roll specialness: adverse selection and liquidity. A few additional considerations—including prepayment risk borne by the roll buyer, default risk, and settlement failures—are discussed and tested in Section 8.

3.1.1 Redelivery risk and adverse selection

As we discussed in the previous section, a key feature of financing MBS by dollar roll, relative to financing by repo, is that the roll buyer (who lends cash and receives an MBS) has the option to deliver a substantially similar but different MBS in the future month of the roll contract. As a compensation, the roll seller offers a lower price to buy back the substantially similar MBS in the future-month leg. This low price, in turn, implies a lower effective financing rate, or a higher specialness.

To illustrate the formal link between dollar roll specialness and adverse selection imbedded in dollar roll contracts, we consider the following simple, stylized model.

There are three periods, $t \in \{0, 1, 2\}$. The discount rate is r per period. Multiple MBS CUSIPs of the same cohort, indexed by $i \in \{1, 2, \ldots, n\}$, trade in the market. Investors are risk-neutral. For simplicity, suppose that all MBS have the same coupon rate $c > 0$ and maturity at $t = 2$. These MBS, however, have heterogeneous prepayment speeds. In particular, for MBS i, a random fraction λ_i of the underlying mortgages will be prepaid at $t = 1$ and the remaining fraction $1 - \lambda_i$ will be paid at $t = 2$. This information is unobservable ex ante. Thus, the time-0 value of a generic MBS is

$$\begin{aligned} P_0 &= \mathbb{E}\left[\lambda_i \frac{1+c}{1+r} + (1-\lambda_i)\left(\frac{c}{1+r} + \frac{1+c}{(1+r)^2}\right)\right] \\ &= \frac{c}{1+r} + \frac{1+c}{(1+r)^2} - \frac{c-r}{(1+r)^2}\mathbb{E}[\lambda_i]. \end{aligned} \tag{2}$$

If $c > r$, prepayment lowers (premium) MBS value; if $c < r$, prepayment increases (discount) MBS value. Suppose that strictly between $t = 0$ and $t = 1$ all $\{\lambda_i\}$ become public information.

Now consider a dollar roll contract transacted at time $t = 0$. For simplicity, suppose that the front-month leg is settled at $t = 0$ and the future-month leg is settled at $t = 1$. One may worry that such a dollar roll schedule abstracts away from the uncertainty faced by the roll buyer regarding the value of the MBS collateral because the transaction date and the front-month settlement date are not necessarily the same in reality. In fact, however, this uncertainty is limited in reality because most of the dollar roll transactions happen shortly before the front-month settlement date when investors (both sellers and buyers of the dollar roll) have a good idea about what CUSIPs constitute the cheapest-to-deliver cohort.

Also for simplicity and to focus on the adverse selection channel, suppose that the MBS coupon and principal (if prepaid) are paid after the future-month leg of the dollar roll transaction, so all cash flows are paid to the roll seller at $t = 1$. (In practice, the cash flows during the funding period go to the dollar roll buyer, who is consequently exposed to prepayment risk. See Section 8.2 for more discussion and analysis on this point.) At $t = 0$, the roll seller delivers the roll buyer an MBS with value P_0. At $t = 1$, the roll buyer delivers back a potentially different MBS with the time-1 value

$$P_1(\lambda_i) = \lambda_i(1+c) + (1-\lambda_i)\left(c + \frac{1+c}{1+r}\right) = c + \frac{1+c}{1+r} - \frac{c-r}{1+r}\lambda_i. \tag{3}$$

Clearly, since the roll buyer has the option to redeliver any MBS at $t = 1$, he would deliver the cheapest. That is, the redelivered MBS has value $\min_i P_1(\lambda_i)$.

The effective financing rate R implied from the dollar roll contract satisfies

$$P_0 = \frac{1}{1+R}\mathbb{E}\left[\min_i P_1(\lambda_i)\right], \tag{4}$$

which gives

$$R = \frac{\mathbb{E}\left[\min_i P_1(\lambda_i)\right]}{P_0} - 1 = \frac{c + \frac{1+c}{1+r} + \mathbb{E}\left[\min_i\left(-\frac{c-r}{1+r}\right)\lambda_i\right]}{\frac{c}{1+r} + \frac{1+c}{(1+r)^2} - \frac{c-r}{(1+r)^2}\mathbb{E}[\lambda_i]} - 1. \tag{5}$$

Depending on $c > r$ or $c < r$, we have

$$r - R = 1 + r - \frac{c + \frac{1+c}{1+r} + \mathbb{E}\left[\min_i\left(-\frac{c-r}{1+r}\right)\lambda_i\right]}{\frac{c}{1+r} + \frac{1+c}{(1+r)^2} - \frac{c-r}{(1+r)^2}\mathbb{E}[\lambda_i]} = \begin{cases} \frac{\frac{c-r}{1+r}(\mathbb{E}[\max_i \lambda_i] - \mathbb{E}[\lambda_i])}{\frac{c}{1+r} + \frac{1+c}{(1+r)^2} - \frac{c-r}{(1+r)^2}\mathbb{E}[\lambda_i]}, & \text{if } c > r \\ \frac{\frac{r-c}{1+r}(\mathbb{E}[\lambda_i] - \mathbb{E}[\min_i \lambda_i])}{\frac{c}{1+r} + \frac{1+c}{(1+r)^2} + \frac{r-c}{(1+r)^2}\mathbb{E}[\lambda_i]}, & \text{if } c < r. \end{cases} \tag{6}$$

Therefore, for MBS not priced at par, the specialness depends on the effective heterogeneity of expected prepayment speeds ($\mathbb{E}[\max_i \lambda_i] - \mathbb{E}[\lambda_i]$ or $\mathbb{E}[\lambda_i] - \mathbb{E}[\min_i \lambda_i]$) within the TBA cohort. The higher the effective heterogeneity, the higher the specialness.

To get more intuition and motivate our empirical measurement of the effective heterogeneity of expected prepayment speeds, we further suppose that

$$\lambda_i = \lambda\alpha_i, \tag{7}$$

where the random variable λ captures the common prepayment speed of the cohort, the scaling factor $\alpha_i > 0$ captures the individual prepayment characteristics of mortgages that underly MBS i, and λ and $\{\alpha_i\}$ are uncorrelated. Without loss of generality, we can normalize the mean of α_i to be one: $\mathbb{E}[\alpha_i] = 1$. Substituting these parametric specifications into the expression of R, we get the specialness

$$r - R = \begin{cases} \frac{c-r}{1+r} \cdot \frac{\mathbb{E}[\lambda]}{\frac{c}{1+r} + \frac{1+c}{(1+r)^2} - \frac{c-r}{(1+r)^2}\mathbb{E}[\lambda]} \cdot \left(\mathbb{E}[\max_i \alpha_i] - \mathbb{E}[\alpha_i]\right), & \text{if } c > r, \\ \frac{r-c}{1+r} \cdot \frac{\mathbb{E}[\lambda]}{\frac{c}{1+r} + \frac{1+c}{(1+r)^2} + \frac{r-c}{(1+r)^2}\mathbb{E}[\lambda]} \cdot \left(\mathbb{E}[\alpha_i] - \mathbb{E}[\min_i \alpha_i]\right), & \text{if } c < r. \end{cases} \tag{8}$$

The expression (8) has a simple intuition. All else equal, the specialness of a particular MBS cohort in the dollar roll market increases in the expected cohort-level prepayment speed, $\mathbb{E}[\lambda]$, as well as the the heterogeneity of individual MBS prepayment characteristics under the same cohort, captured by $\mathbb{E}[\max_i \alpha_i] - \mathbb{E}[\alpha_i]$ or $\mathbb{E}[\alpha_i] - \mathbb{E}[\min_i \alpha_i]$. The expression (8) also makes it clear that the positive relation between specialness and cohort-level prepayment speed $\mathbb{E}[\lambda]$ is valid for both premium and discount MBS. Intuitively, while a high cohort-level prepayment speed implies a low and high MBS value for premium and discount securities, respectively, it always leads to a larger value gap of the cheapest-to-deliver MBS and other MBS under the same cohort, hence a higher redelivery risk and higher specialness.

3.1.2 Liquidity effect

So far, we have discussed the effect of redelivery risk for the specialness of dollar roll, which is unique to the MBS market. Now, we turn to the generic effect of liquidity for determining dollar roll specialness. Specifically, the agency MBS market is over-the-counter (OTC), similar to Treasury, corporate bond, municipal bond, and repo markets. An important feature of OTC markets is search friction: market participants must first locate a counterparty to execute a trade or borrow a security.

Empirical studies in Treasury markets generally find that a lower liquidity is associated with a higher specialness (Jordan and Jordan (1997) and Graveline and McBrady (2011)). Closely related, Krishnamurthy (2002) finds a negative relation between on-the-run premium and issue size in U.S. Treasury markets. Using a theoretical model with search frictions and heterogeneous beliefs, Duffie, Garleanu, and Pedersen (2002) show that a larger supply reduces the lending fee and price of an asset in two ways. First, a larger asset supply implies a lower valuation or belief of the marginal holder of the asset. Second, a larger asset supply makes it easier for pessimists to locate the asset for shorting, which, in turn, reduces the lending fee and the asset price. Since a smaller lending fee corresponds to a higher effective financing cost for the security lender (i.e. cash borrower), their model predicts that specialness is lower if the asset supply is larger.[14]

In a similar vein, dollar roll specialness should increase in the illiquidity of the agency MBS market. Specifically, if MBS supply for dollar roll trading is scarce, it is more costly for roll buyers to locate these MBS due to search frictions. Roll sellers who hold the scarce MBS will command a compensation and hence low borrowing rate for giving up these MBS to roll buyers in the funding period. Note that the illiquidity here is due to the scarcity of CTD MBS collateral that are specific to dollar roll trading, rather than any agency MBS collateral qualified for GC repo trading. Consequently, this illiquidity will affect the dollar roll more than the repo, leading to high specialness. In sum, we expect that dollar roll specialness is negatively associated with MBS liquidity.

3.2 Relation between dollar roll specialness and MBS returns

As we have discussed, a dollar roll can become more special for two reasons: a higher adverse selection associated with redelivery risk or a lower liquidity. For both channels, dollar roll specialness is negatively related to the expected MBS returns. The generic rationale is that a high specialness of an MBS gives its holders a "convenience yield" in the financing market, and these holders are willing to accept a lower expected return in the cash market, as illustrated in Duffie (1996) and Duffie, Garleanu, and Pedersen (2002).

A unique feature of dollar roll specialness is that the adverse selection channel narrows down the effective supply and liquidity of the MBS cohort to the cheapest-to-deliver pool of MBS, as investors rationally redeliver the cheapest CUSIPs in the future-month leg of dollar roll contracts. By definition, this effective supply of an MBS cohort, comprising of cheapest-to-deliver MBS CUSIPs, is smaller than the supply of all CUSIPs in the MBS cohort. Even if the total supply of MBS in a cohort stays constant (which implies zero specialness due to the general liquidity channel), a higher adverse selection can shrink the effective supply of the MBS cohort and make it on special. This endogenous feedback between adverse selection and supply is unique to dollar roll and different from the total supply channel that is also present in repo market, though both induce a negative relation between the specialness and expected MBS return as discussed above.

[14]Not all theories of OTC markets generate unambiguous predictions about the relation between asset supply and specialness. For example, Vayanos and Weill (2008) characterize the endogenous concentration of liquidity and trading activity in one asset even if there is another identical asset. They show that, if the supply of Asset 1 exceeds that of Asset 2 by a sufficient amount, short sellers concentrate on Asset 1. In this equilibrium, a decrease in the supply of Asset 1 can lead to a higher or a lower specialness of Asset 1. This ambiguous prediction comes from the interaction between scarcity in the repo market and scarcity in the spot market.

4 Data

Our empirical analysis employs two main proprietary data sets. The first comprises observations of dollar roll implied financing rates (IFRs), option-adjusted spreads (OAS), and (realized) single monthly mortality rates (SMM) for FNMA 30-year (generic) TBA contracts for the next two delivery months and with twelve coupon rates ranging from 3% to 8.5% from January 2000 to July 2013. These variables are furnished by J.P. Morgan. The dollar roll financing rates are computed based on expected prepayment rate from their proprietary prepayment model that is recalibrated to historical data every month. The option-adjusted spread is a spread added to the term structure of interest rates such that the present value of an MBS' expected cash flows, after adjusting for the value of homeowners' prepayment options conditional on the interest rate path, equals the price of the security.[15] Intuitively, the OAS measures the expected return an investor earns, relative to certain benchmark interest rates, by buying the MBS and hedging out the expected prepayments. The (realized) single monthly mortality rate equals the realized prepayment amount as a percentage of the previous month's outstanding balance minus this month's scheduled principal payment. The SMM is a widely used measure of monthly prepayment rate (see Hayre (2001)).[16]

The IFR, OAS, and SMM data are available at the daily frequency. We construct monthly series to (1) align with other important variables that are only available at the monthly frequency, such as the supply of the CTD cohort and MBS characteristics; and (2) reduce noises associated with microstructure effects. Specifically, our monthly series are constructed as averages from seven trading days to three trading days (both inclusive) before the settlement date of each month.[17] As shown by Gao, Schultz, and Song (2015), dollar roll trading

[15] Specifically, let $r_t, t = 1, \cdots, T$ be the path of one-period interest rate with a realization of $r_{jt}, t = 1, \cdots, T$ under the economy state $j = 1, \cdots, N$. With a prepayment model that specifies the prepayment behavior of the homeowner conditional on the realized interest rate path under state j, the cash flow path from the MBS $C_{jt}, t = 1, \cdots, T$ can be calculated. Then the OAS is defined such that

$$V_{MBS} = \sum_{j=1}^{N} p_j \left[\sum_{t=1}^{T} \frac{C_{jt}}{(1 + r_{j1} + OAS) \times \cdots (1 + r_{jt} + OAS)} \right],$$

where p_j is the probability of state j. That is, the OAS is the yield spread to the interest rate r_t required to set the present value of the MBS expected cash flows based on the prepayment forecast equal to the market prices of this MBS.

[16] Our results (presented later) do not hinge on the J.P. Morgan data set. We obtained similar main results using the IFR and OAS data from Barclays, confirming the robustness of our results to different dealers' prepayment models. Moreover, although dealers update their prepayment models periodically, our IFR and OAS series are computed under the same prepayment model of J.P. Morgan over our sample period, so that the data contain no artificial discontinuities due to potential updates of the prepayment model.

[17] We also conducted our main empirical analysis using the end-of-month series, the first-Friday series, and

volumes are concentrated in this period of the month. Moreover, close to the settlement date of the front-month leg, the roll buyer faces little uncertainty regarding the value of the MBS collateral that he receives, because investors (both sellers and buyers of the dollar roll) generally have a good idea about what CUSIPs constitute the cheapest-to-deliver cohort a few days before the settlement date. Overall, our first main data set is an unbalanced panel, with the common last observations in July 2013 but varying initial observations between January 2000 and August 2010.

Our second main proprietary data set contains the monthly characteristics of all available TBA-eligible FNMA 30-year MBS CUSIPs. For each MBS CUSIP, this data set reports the average FICO score, average loan-to-value ratio (LTV), remaining principal balance, the percentage of the refinance loans, weighted average coupon rate (WAC), weighted average maturity (WAM), production year, and issuance amount. These data are obtained from eMBS and are available from July 2005 through July 2013.

Panel A of Table 1 provides summary statistics of IFRs, in basis points. We observe that the time series mean of IFRs increases with the coupon rate, with negative values for coupon rates from 3% to 4%. For all coupon levels, the time-series minimum IFRs are negative, reaching as low as −13% for the 7% coupon cohort. We compute two versions of dollar roll specialness, DSP^{GC} and DSP^{LIBOR}, using the 1-month general collateral (GC) repo rate of agency MBS and the 1-month LIBOR as benchmark prevailing interest rates, respectively.[18] We obtain the ICAP GC repo rate of MBS from Bloomberg and LIBOR from Datastream. Panels B and C of Table 1 report summary statistics of DSP^{GC} and DSP^{LIBOR}, respectively. Overall, the average specialness has an approximate range between 20 and 100 basis points if positive, and the time-series mean of dollar roll specialness generally decreases with the coupon rate (which is due to the "burnout effect" that we discuss in the last part of Section 5). Specialness for coupon rates from 7.5% to 8.5% is negative on average. Unsurprisingly, DSP^{GC} is lower than DSP^{LIBOR} because the GC repo rate of MBS is usually below the 1-month LIBOR. Panel D of Table 1 presents the fraction of time when dollar roll is "on special." We observe that dollar roll specialness is positive in over 65% of the sample period for TBA contracts with coupon rates less than 7%. MBS with very low coupons, e.g., from 3% to 4%, and the "current coupon" MBS (with a coupon rate that makes its price equal to par) are almost always special.

Figure 3 shows the time series behavior of the dollar roll specialness of FNMA 30-year

the calendar-month-average series. The results are similar.

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

Table 1: Summary Statistics of Dollar Roll Financing Rates and Specialness

Coupon (%)	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	CC
A: Dollar Roll Financing Rates													
Mean	-78.6	-72.7	-12.4	152	131.5	221.1	241.2	233.5	227.6	349.1	385.8	464.3	222
Std	77.1	93.4	40.6	219.8	224.1	247.2	238.6	254.2	280.7	225.7	206.4	155.5	249.4
Min	-260.6	-511.6	-204.6	-197.4	-230.2	-216	-143.3	-670.3	-1363.1	-1098.5	-406.3	58	-610.8
Max	20.6	18	43.6	539.7	544.8	683.2	676.2	668.3	659.7	675.6	865	934.8	651.7
B: DSP^{GC}													
Mean	104.8	101.3	40.9	36	53.7	33.3	19.6	27.3	33.3	-88.2	-125	-203.4	38.9
Std	76.3	100.9	46.3	62.6	71.5	63.6	60.3	85	135.2	176.4	202.2	226.6	72.5
Min	6.2	2.6	-15.6	-187.6	-192.1	-202.7	-216.1	-217.8	-252.7	-516.5	-648.2	-909.1	-198.4
Max	291.4	604.7	288.8	299.3	257.2	230.8	187.6	691.8	1384.7	1120	427.9	218.2	641.8
C: DSP^{LIBOR}													
Mean	101.7	99.1	39.7	41	58.7	39.6	26	33.8	39.7	-81.8	-118.5	-197	45.3
Std	77.9	97.5	47.1	58.2	66.4	60.7	57.8	82.6	134	178.8	203.5	229.1	69.6
Min	5.7	2.2	-22.9	-168.4	-173	-183.6	-214	-198.7	-254.7	-521.3	-652.9	-911	-179.3
Max	286.8	563.1	301.6	303.1	253.9	235.3	191.7	693.2	1386	1121.4	429.2	225.6	635.4
D: Ratio of "On Special"													
Begin	08/2010	12/2008	12/2008	05/2003	08/2002	11/1998	07/1998	07/1998	07/1998	07/1998	07/1998	07/1998	07/1998
End	07/2013	07/2013	07/2013	07/2013	07/2013	07/2013	07/2013	07/2013	07/2013	07/2013	07/2013	07/2013	07/2013
No.	36	56	56	123	132	177	181	181	181	181	181	181	181
"Special"%													
-GC	100%	100%	96%	80%	82%	72%	64%	69%	64%	31%	36%	20%	88%
-LIBOR	100%	100%	95%	88%	90%	81%	71%	75%	70%	35%	36%	22%	94%

Note: This table provides summary statistics of the financing rates, specialness relative to both the GC repo rate and LIBOR, and the ratio of dollar roll being on special in the time series, across coupon rates. The values of financing rates and specialness are denoted in basis points. The last column "CC" refers to "current-coupon MBS", which is the MBS with a coupon rate that makes its price equal to par. The overall sample period is January 2000 to July 2013, with various starting dates that depend on coupon rates.

MBS that are priced the closest to par. We observe large variations of dollar roll specialness over time, which reflects time-varying funding conditions in the agency MBS market. Specialness shot up to as high as 230 basis points in early 2012.

We use OAS based on both the LIBOR swap yield curve and the Treasury yield curve, denoted by OAS^{LIBOR} and OAS^{Tsy}, respectively. Since the LIBOR and Treasury yields are benchmark interest rates, OAS^{LIBOR} and OAS^{Tsy} can be regarded as spreads relative to investors' funding costs.[19] We calculate monthly OAS time series in each month. Table 2 provides summary statistics of these OAS series. We observe that the time-series means of OAS^{LIBOR} range from 6 to 160 basis points, and those of OAS^{Tsy} range from 20 to 200 basis points. Both generally increase with the coupon rates, and the monotonic increasing pattern is more pronounced for OAS^{Tsy} than for OAS^{LIBOR}. Figure 3 plots the monthly time series of OAS^{LIBOR} and OAS^{Tsy} for near-current coupon FNMA 30-year MBS.

In the next three sections, we present the empirical results on the determinants of dollar roll specialness, the relation between specialness and expected MBS returns, and the impact of the Federal Reserve's large scale asset purchases (LSAP) of agency MBS on dollar roll specialness in the recent financial crisis period.

5 What Drives Dollar Roll Specialness?

5.1 Empirical measure

As discussed in Section 3.1, the specialness of a dollar roll depends on adverse selection and liquidity.

Equation (8) suggests that an important determinant of the adverse selection component is the expected cohort-level prepayment speed ($\mathbb{E}[\lambda]$). We focus on this expected cohort-level prepayment speed in capturing redelivery risk, which is measured by the monthly prepayment rate SMM_{it}, where i is a TBA coupon rate and t is a month. This single-month mortality rate can be computed from the conditional prepayment rate (CPR)[20] by $SMM = 1 - (1 - CPR)^{1/12}$. (On the other hand, the within-cohort heterogeneity in prepayment characteristics ($\mathbb{E}[\max_i \alpha_i] - \mathbb{E}[\alpha_i]$ or $\mathbb{E}[\alpha_i] - \mathbb{E}[\min_i \alpha_i]$) is much more difficult to measure in the data.)

[19] A few studies including Fabozzi and Mann (2011) and Belikoff, Levin, Stein, and Tian (2010) argue that OAS^{LIBOR} is a better measure of the two as most investors use LIBOR as the benchmark borrowing rate and LIBOR swap rates are quoted more uniformly and densely.

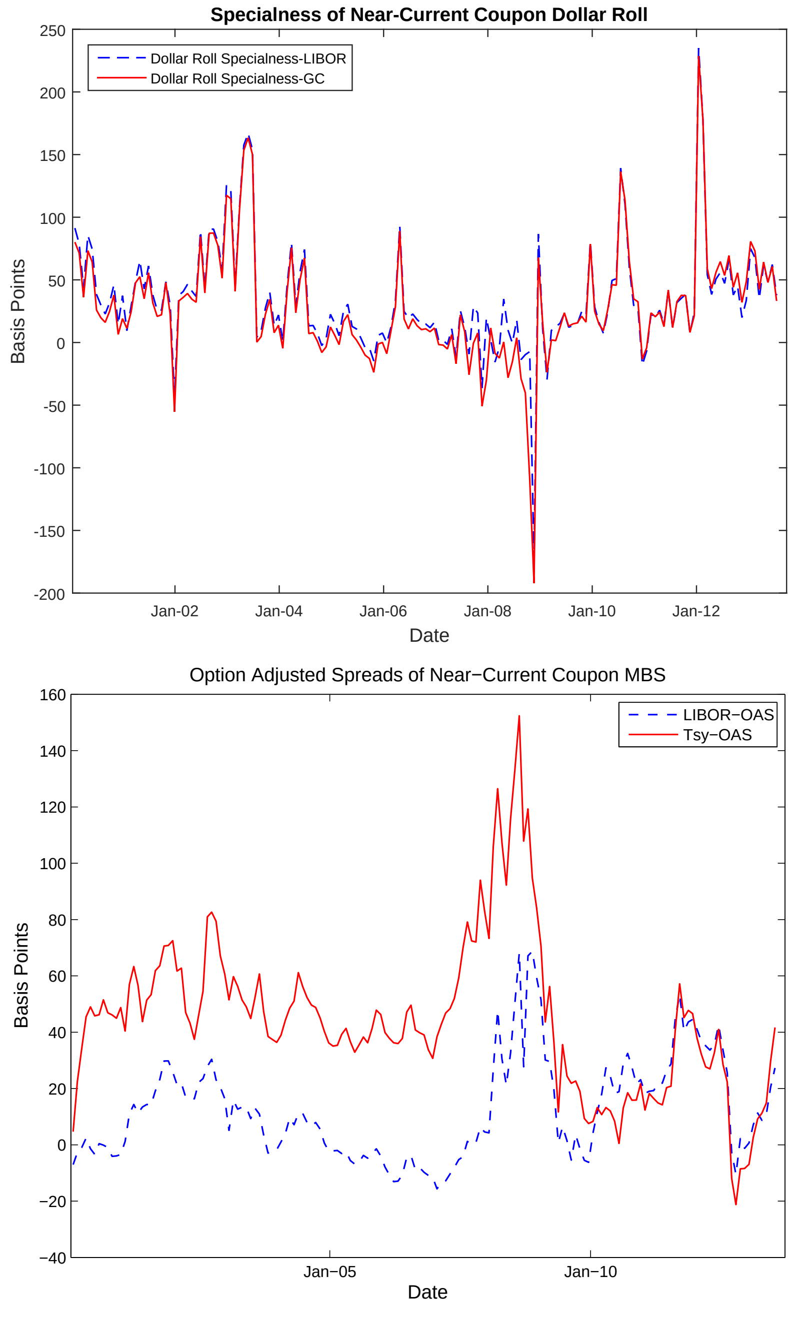
[20] The conditional prepayment rate is the proportion of the principal of a pool of mortgage loans that is prepaid each year.

Table 2: Summary Statistics of Option-Adjusted Spreads

	OAS^{LIBOR}												
Coupon (%)	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	CC
Mean	32.02	19.98	15.3	13.55	5.99	12.36	15.65	21.1	32.89	91.85	113.31	162.63	11.68
Std	27.08	19.99	12.97	21.39	27.35	25.64	30.63	36.74	47.05	120.8	152.41	176.41	17.52
Min	-19.69	-31.19	-11.27	-37.72	-85.89	-63.76	-71.33	-35.89	-45.05	-41.15	-82.55	-55.61	-15.64
Max	82.93	75.89	59.52	81.94	75.95	109.97	150.09	191.4	220.96	377.64	424.9	493.37	68.69
	OAS^{Tsy}												
Mean	28.99	22.98	19.35	43.91	37.79	39.28	43.55	50.7	67.4	128.56	150.94	203.07	43.44
Std	27.48	24.41	16.67	33.83	39.95	35.68	38.64	41.75	49.42	110.16	139.88	163.68	27.1
Min	-28.41	-35.42	-15.66	-37.77	-82.54	-58.89	-67.85	-23.4	-12.9	-5.63	-43.44	-17.08	-21.22
Max	75.33	104.5	81.84	158.92	150.89	151.4	171.43	204.48	253.86	389.99	438.01	507.21	152.36

Note: This table provides summary statistics of monthly series of OAS^{LIBOR} and OAS^{Tsy} across coupon rates. The OAS values are denoted in basis points. The last column "CC" refers to "current-coupon MBS", which is the MBS with a coupon rate that makes its price equal to par. The overall sample period is January 2000 to July 2013, with various starting dates that depend on coupon rates.

Figure 3: Specialness and OAS of Near-Current Coupon Dollar Roll



Note: This figure plots monthly time series of the specialness, as well as OAS^{LIBOR} and OAS^{Tsy}, of FNMA 30-year MBS that are priced the closest to par, from January 2000 to July 2013. The dollar roll specialness is computed both relative to the 1-month GC repo rate of agency MBS and to the 1-month LIBOR.

To capture the liquidity effect, one reasonable proxy is the available supply of MBS to settle dollar roll trades.[21] Importantly, the supply measure should be about the *CTD cohort*, i.e., those CUSIPs most advantageous to deliver into TBA contracts by investors, rather than the total outstanding balance of all MBS. To the best of our knowledge, there are no readily available data that tell whether an MBS CUSIP is part of the CTD cohort. Thus, we construct the set of CTD cohort based on criteria similar to those in Himmelberg, Young, Shan, and Henson (2013), using data on MBS characteristics. Specifically, for each TBA coupon 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 average LTV ratio is above 85%, and the average FICO score is below 680. These characteristics make prepayment less likely; thus, the associated CUSIPs have more predictable values and are unlikely to become part of the CTD cohort. Adding up the outstanding amount of the remaining CUSIPs gives us a measure of the (raw) supply of CTD MBS CUSIPs for each TBA coupon i in each (TBA settlement) month t, denoted $Supply_{it}^{CTD}$.[22]

We further adjust $Supply_{it}^{CTD}$ by the demand for the CTD cohort to get a measure of the *net* CTD supply. As discussed in Section 2, one important source of TBA demand is the amount of CMO deals that MBS dealers need to cover. We obtain the monthly agency CMO volume from Bloomberg and subtract it from $Supply_{it}^{CTD}$ to get a net-supply measure, denoted as $NSupply_{it}^{CTD}$.[23]

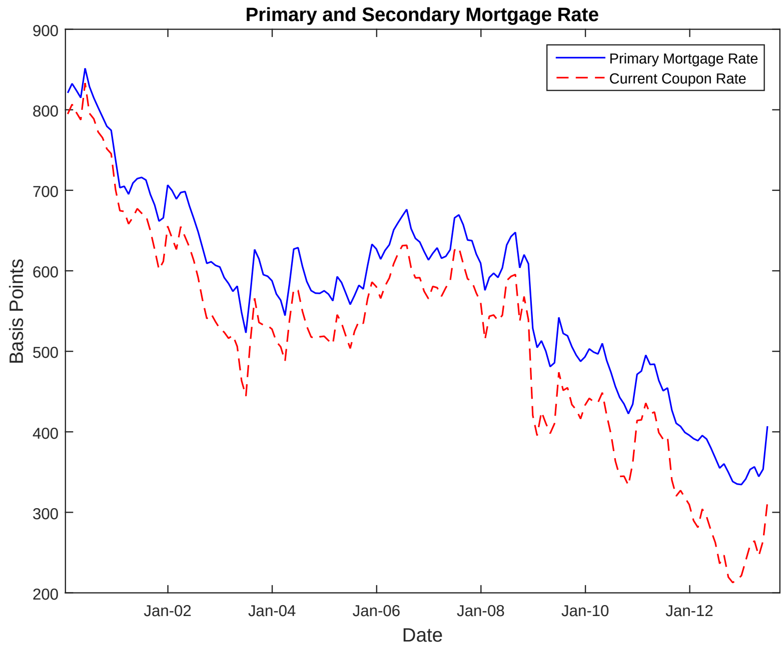
Table 3 reports the summary statistics of SMM and $NSupply^{CTD}$ across coupons. We observe that the average prepayment rate in our sample period increases with coupons for coupon buckets less than 7% and decreases thereafter. The highest monthly prepayment rate is 3.35% for the 7% coupon MBS. The monthly average of the net supply of CTD MBS is all above \$100 billion for coupons below 6%, and decreases from \$20 billion to only \$6 million

[21]Other common measures of liquidity, such as trading volume or bid-ask spread, rely on transaction data, which are unavailable until 2011 when post-trade transparency in MBS was introduced by FINRA.

[22]The MBS supply variables are available at the end of calendar month, whereas our time index t refers to TBA settlement month. Since the settlement date is usually around the 12th or 13th of a calendar month, $Supply^{CTD}$ for settlement month t is recorded at the end of calendar month $t-1$. The same applies to the measure $NSupply^{CTD}$ that we define below.

[23]Bloomberg provides the monthly agency CMO volume across coupon rates, but no further breakdown across agencies. To obtain the monthly CMO volume of *FNMA* across coupons, we multiply the CMO volume in each coupon bucket by the aggregate ratio of the FNMA CMO (relative to other agencies) for each month. The computed FNMA CMO volume combines both the 30-year and 15-year collateral. Hence $NSupply_{it}^{CTD}$ underestimates the CTD supply, which goes against our results. Therefore, our results are conservative and the regression coefficients $NSupply_{it}^{CTD}$ in the following sections should be interpreted as a lower bound. Moreover, results using $Supply_{it}^{CTD}$ are similar.

Figure 4: Primary and Secondary Mortgage Rates



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, and current-coupon (CC) mortgage rate, from January 2000 to July 2013.

as the coupon increases from 6.5% to 8.5%. This is unsurprising given that the primary mortgage rate decreased from 8.5% to 3.5% in our sample period, which shifted the MBS issuance from high to low coupons (see Figure 4).

5.2 Results

Table 4 reports panel regressions based on the following model:

$$DSP_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta_1 \cdot SMM_{it} + \beta_2 \cdot NSupply_{it}^{CTD} + \epsilon_{it}, \qquad (9)$$

where DSP_{it} is either DSP_{it}^{GC} or DSP_{it}^{LIBOR}, and D_i and D_t are coupon dummies and time dummies, respectively. The time dummies control both the time-series persistence in the data and the effect of certain pure time-series factors, such as interest rate volatility, financial constraints of financial intermediaries, and house prices, which may also affect dollar roll specialness (Gabaix, Krishnamurthy, and Vigneron (2007)). We report robust

Table 3: Summary Statistics of SMM and $NSupply^{CTD}$

	SMM											
Coupon (%)	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5
Mean	0.221	0.736	0.908	1.308	1.461	1.768	2.069	2.632	3.354	3.318	3.323	2.694
Std	0.171	0.829	1.099	1.367	1.77	1.614	1.841	2.379	2.682	2.97	3.52	2.56
Min	0.008	0.042	0.05	0.05	0.05	0.067	0.101	0.101	0.168	0.211	0.017	0.008
Max	0.585	3.563	3.44	4.41	6.42	6.048	10.705	19.415	20.79	24.196	35.695	11.495
N	22	36	56	61	123	132	163	163	163	163	163	163
	$NSuppy^{CTD}$											
Mean	-	119.589	144.891	259.531	113.016	123.261	101.358	19.563	4.438	0.167	0.053	0.006
Std	-	134.827	63.414	111.994	55.999	61.16	47.126	8.149	2.081	0.094	0.039	0.007
Min	-	-0.777	-2.249	-1.578	-0.381	0.001	-0.143	0.001	0.001	0.015	-0.023	-0.039
Max	-	330.104	236.396	392.256	199.758	218.286	181.561	31.698	7.96	0.311	0.113	0.02
N	0	34	55	56	70	70	70	70	70	68	68	68

Note: This table provides summary statistics of monthly series of SMM and $NSupply^{CTD}$ across coupon rates, in percentage points and billions of U.S. dollars, respectively. The overall sample period is January 2000 to July 2013, with various starting dates that depend on coupon rates.

t-statistics in parentheses that correct for serial correlation in the residuals clustered at the coupon level.

Table 4: Determinants of Dollar Roll Specialness

	DSP^{GC}			DSP^{LIBOR}		
	(1)	(2)	(3)	(4)	(5)	(6)
SMM	7.7540**	21.7924**		7.7540**	21.7924**	
	(3.1705)	(4.3227)		(3.1705)	(4.3227)	
$\text{NSupply}^{\text{CTD}}$	-0.1810+		-0.2023*	-0.1810+		-0.2023*
	(-2.1288)		(-2.2670)	(-2.1288)		(-2.2670)
N	719	1,408	719	719	1,408	719
R^2	0.8116	0.6346	0.8076	0.8080	0.6299	0.8039
Coupon Effect	Yes	Yes	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table reports panel regressions based on the following model:

$$DSP_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta_1 \cdot SMM_{it} + \beta_2 \cdot NSupply_{it}^{CTD} + \epsilon_{it},$$

where DSP_{it} is either DSP_{it}^{GC} or DSP_{it}^{LIBOR}, and D_i and D_t are coupon dummies and time dummies, respectively. Robust t-statistics are reported in parentheses based on clustered standard errors at the coupon level. 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 2000 to July 2013, with various starting dates that depend on coupon rates.

Results from Table 4 confirm our hypothesis: a higher prepayment speed, SMM, is associated with a higher dollar roll specialness, whereas a higher net supply, $NSupply^{CTD}$, is associated with a lower specialness. The economic magnitudes are also large. For example, reading from column (1), a 2.54 percentage point increase in SMM, which is roughly one standard deviation of SMM across time and coupon in our sample, increases dollar roll specialness by about 20 basis points ($= 7.7540 \times 2.54$); and a \$99.26 billion increase in the available supply of the CTD cohort, which is roughly one standard deviation of the balance of the CTD cohort across time and coupon in our sample, decreases specialness by 18 basis points ($= -0.1810 \times 99.26$). We also run univariate panel regressions with only one of SMM and $NSupply^{CTD}$ on the right-hand side, and the results in columns (2), (3), (5), and (6) further confirm the significant impact of adverse selection and liquidity on dollar roll specialness. In all these regressions, using DSP_{it}^{GC} and DSP_{it}^{LIBOR} yields essentially identical coefficients.

5.3 Alternative measures of prepayment speed

We have shown that a higher cohort-level prepayment speed, SMM_{it}, is associated with a higher dollar roll specialness. In this subsection we explore two alternative cohort-specific measures of prepayment speed that are coarser than SMM but come from first principles.

The first alternative measure of cohort-specific prepayment speed is the "burnout effect" (BO), an interesting feature unique to the mortgage markets. The burnout effect says that mortgage borrowers who had refinancing opportunities in the past, but chose not to take them, are less likely to prepay and refinance in the future if mortgage rates fall. The essence of the burnout effect is that reactions to past refinancing opportunities reveal some unobservable characteristics ("types") of borrowers. To see the intuition, consider the following stylized example. Suppose that mortgage rates have dropped from 5% last year to 4% this year. Borrowers who benefit most from refinancing at lower rates, and are able to do so, probably will have already refinanced this year; therefore, their new mortgage loans with lower interest rates of 4% enter the pool of MBS with coupon rates around 4%. By contrast, borrowers still paying the 5% mortgage interest this year, despite the lower prevailing rate, signal a high effective cost of refinancing: the household could have an impaired credit, a low home equity value, or a small remaining loan balance, among other reasons. All these characteristics make the households that keep the 5% mortgage loan less likely to refinance in the future even if rate drops further.

We measure the time-t burnout effect of a TBA cohort with coupon rate CP_i as

$$BO_{it} = \sum_{s=1}^{t-1} (WAC_{is} - PMMS_s) 1_{(WAC_{is} > PMMS_s)}, \tag{10}$$

where $1_{\{WAC_{is} > PMMS_s\}} = 1$ if the original coupon rate is higher than the mortgage rate at time s, and 0 otherwise. The original coupon rate is measured by the weighted average coupon (WAC) of all MBS in the CTD cohort identified above, weighted by the remaining balance, while the current mortgage rate is measured by the primary mortgage rate $PMMS_t$ for 30-year fixed-rate mortgage loans from the Freddie Mac primary mortgage market survey, available at the weekly frequency (we use the first-week series to align with the monthly series of all other variables). Conditional on $WAC_{is} > PMMS_s$, the higher is $WAC_{is} - PMMS_s$, the further the mortgage rate falls below the original coupon rate and hence the more the MBS is "burned." Hence, BO_{it} captures the cumulative past exposure up to time t of the MBS to low mortgage rates (Hall (2000)).

The second alternative measure of cohort-specific prepayment speed is the value of mortgage borrowers' prepayment options. At first sight, it may appear that we should use coupon cohorts that are currently in the money, that is, the prevailing mortgage rates are lower than the coupon rates. But the burnout effect discussed above suggests that mortgage borrowers underlying MBS cohorts with in-the-money coupons are, by revealed preference, less rate-sensitive. To avoid overlapping with the burnout effect measure, we exclude in-the-money coupon cohorts and focus on out-of-the-money cohorts. Specifically, we measure the current prepayment incentive of the TBA cohort with coupon CP_i at time t by the difference between the original coupon rate and the current mortgage rate:

$$PI_{it} = 1_{\{WAC_{it}<PMMS_t\}} \left(WAC_{it} - PMMS_t\right), \tag{11}$$

where $1_{\{WAC_{it}<PMMS_t\}} = 1$ if the original coupon rate is lower than the current mortgage rate, and 0 otherwise. Conditional on $WAC_{it} < PMMS_t$, the less negative is $WAC_{it} - PMMS_t$, the more valuable is the prepayment option. Put differently, mortgage borrowers' prepayment options are more valuable if the options are less out of the money. (In the data there are almost no data points with $WAC_{it} = PMMS_t$.)

We emphasize that BO and PI are just two of many possible inputs to prepayment models whose output is SMM; hence, we do not have a strong prior that BO or PI alone would capture prepayment speed as well as SMM does.

Table 5 report results from regression

$$DSP_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta_1 \cdot PI_{it} + \beta_2 \cdot NSupply_{it}^{CTD} + \epsilon_{it}, \tag{12}$$

and

$$DSP_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta_1 \cdot BO_{it} + \beta_2 \cdot NSupply_{it}^{CTD} + \epsilon_{it}. \tag{13}$$

We also put PI and BO simultaneously into the same regression. In regressions that include only one of PI and BO at a time, both channels of prepayments have significant impacts on the dollar roll specialness. In particular, the higher the current prepayment incentive, the higher the specialness; the higher the burnout effect, the lower the specialness. If both PI and BO are included, BO remains significant, whereas PI does not.

Table 5: Channels of Prepayment Speed

			DSP^{GC}		
PI	125.8993^{+}		122.8218^{+}		29.0146
	(2.0353)		(1.8602)		(0.6881)
BO		-1.2686**		-1.0674*	-1.0278*
		(-3.7970)		(-2.9058)	(-2.8186)
$\text{NSupply}^{\text{CTD}}$			-0.2707*	-0.3150**	-0.3273**
			(-2.5354)	(-3.4744)	(-3.3469)
N	915	915	719	719	719
R^2	0.7693	0.7968	0.8106	0.8226	0.8228
Coupon Effect	Yes	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes	Yes

			DSP^{LIBOR}		
PI	125.8993^{+}		122.8218^{+}		29.0146
	(2.0353)		(1.8602)		(0.6881)
BO		-1.2686**		-1.0674*	-1.0278*
		(-3.7970)		(-2.9058)	(-2.8186)
$\text{NSupply}^{\text{CTD}}$			-0.2707*	-0.3150**	-0.3273**
			(-2.5354)	(-3.4744)	(-3.3469)
N	915	915	719	719	719
R^2	0.7654	0.7935	0.8070	0.8193	0.8194
Coupon Effect	Yes	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes	Yes

Note: This table reports panel regressions based on the following model:

$$DSP_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta_1 \cdot PI_{it} + \beta_2 \cdot NSupply_{it}^{CTD} + \epsilon_{it},$$

$$DSP_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta_1 \cdot BO_{it} + \beta_2 \cdot NSupply_{it}^{CTD} + \epsilon_{it},$$

and a regression that includes both PI and BO on the right-hand side. Here, DSP_{it} is either DSP_{it}^{GC} or DSP_{it}^{LIBOR}, and D_i and D_t are coupon dummies and time dummies, respectively. Robust t-statistics are reported in parentheses based on clustered standard errors at the coupon level. 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 2000 to July 2013, with various starting dates that depend on coupon rates.

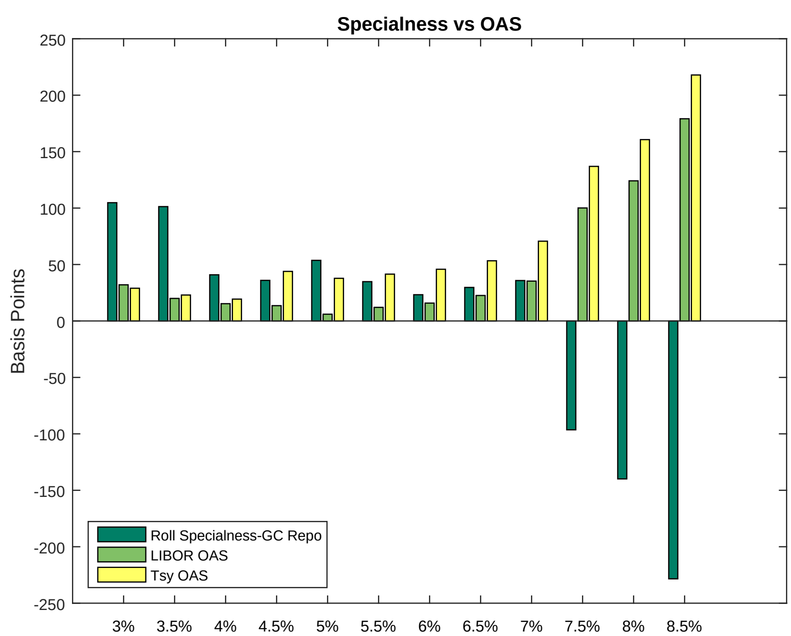
6 Dollar Roll Specialness and Expected MBS Returns

In this section, we study the relation between doll roll specialness and expected MBS returns. We find a negative relation, as hypothesized in Section 3.2.

A commonly used measure of expected MBS returns is the option-adjusted spread (OAS) (see Gabaix, Krishnamurthy, and Vigneron (2007)). As we discussed in the data section, the OAS is effectively a model-implied yield spread of an MBS relative to a benchmark interest-rate term structure, after adjusting for the value of homeowners' expected prepayment options.

Figure 5 plots the time-series averages of OAS^{LIBOR} and OAS^{Tsy}, together with those of DSP^{GC} across coupon rates. A pronounced negative relation emerges. As coupon rate increases, specialness goes down, but OAS goes up.

Figure 5: Dollar Roll Specialness and OAS across Coupons



Note: This figure plots time series averages of OAS^{LIBOR} and OAS^{Tsy} together with those of DSP^{GC} across coupon rates. The overall sample period is January 2000 to July 2013, with various starting dates that depend on coupon rates.

To quantify the relation between dollar roll specialness and OAS across coupon rates and time, the first two columns of both Panels A and B of Table 6 report panel regressions on the following model:

$$OAS_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta \cdot 1(DSP_{it} > 0) + \epsilon_{it}, \tag{14}$$

where $1(DSP_{it} > 0)$ is the specialness indicator function, taking on the value of 1 if an MBS cohort with coupon CP_i is on special in period t and 0 otherwise, OAS_{it} is either OAS^{LIBOR} or OAS^{Tsy}, and D_i and D_t are coupon dummies and time dummies, respectively. Robust t-statistics are reported in parentheses that correct for serial correlation in the residuals clustered at the coupon level. We observe that an MBS cohort on special has a significant negative premium relative to an otherwise identical MBS cohort. In particular, the negative premium is about 50 and 60 basis points using OAS^{Tsy} and OAS^{LIBOR}, respectively, for both DSP^{GC}_{it} and DSP^{LIBOR}_{it}.

Furthermore, the last two columns of both Panels A and B of Table 6 report panel regressions using the magnitude of dollar roll specialness:

$$OAS_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta \cdot DSP_{it} + \epsilon_{it}, \tag{15}$$

where DSP_{it} is either DSP^{GC}_{it} or DSP^{LIBOR}_{it}. We observe highly significant impact of dollar roll specialness on OAS, regardless of which interest benchmark interest rates are used to compute specialness, which OAS measure is used, and whether coupon and time effects are included. The coefficient estimates are remarkably stable, ranging from -0.50 to -0.41.[24]

Regressing the OAS on dollar roll specialness may suffer from an endogeneity problem as both are outputs from a prepayment model with the same inputs. To investigate the robustness of our results, we use another proprietary data set provided by J.P. Morgan that consists of monthly returns on FNMA 30-year TBA contracts from February 2000 to July 2013. The return series are calculated for a strategy of going long a 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. (Carlin, Longstaff, and Matoba (2014) employ a data set of return series with the same strategy.) By design, these return series do not depend on any model or assumption about mortgage prepayment rates or interest rate paths. We label this returns series the "return on mortgages," or ROM. Regressing ROM on dollar roll specialness is free of the endogeneity problem of regressing OAS on specialness.

[24]We also run the first-difference regression and still find highly significant and negative relation between dollar roll specialness and OAS.

Table 6: Regression of OAS on Specialness

	A: OAS^{LIBOR}				B: OAS^{Tsy}			
$1(DSP^{GC} > 0)$	-60.79**				-54.62**			
	(-4.13)				(-3.95)			
$1(DSP^{LIBOR} > 0)$		-59.90**				-53.36**		
		(-4.15)				(-3.94)		
DSP^{GC}			-0.45**				-0.41**	
			(-7.06)				(-6.39)	
DSP^{LIBOR}				-0.45**				-0.41**
				(-7.11)				(-6.44)
N	1,666	1,666	1,666	1,666	1,666	1,666	1,666	1,666
R^2	0.61	0.61	0.80	0.80	0.61	0.61	0.78	0.78
Coupon Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The first two columns of each panel report panel regressions based on

$$OAS_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta \cdot 1(DSP_{it} > 0) + \epsilon_{it},$$

while the last two columns of each panel report panel regressions based on

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

where $1(DSP_{it} > 0)$ is either $1(DSP_{it}^{GC} > 0)$ or $1(DSP_{it}^{LIBOR} > 0)$, DSP_{it} is either DSP_{it}^{GC} or DSP_{it}^{LIBOR}, OAS_{it} is either OAS^{LIBOR} or OAS^{Tsy}, and D_i and D_t are coupon dummies and time dummies, respectively. Robust t-statistics are reported in parentheses based on clustered standard errors at the coupon level. 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 2000 to July 2013, with various starting dates that depend on coupon rates.

Columns (1) and (2) of Table 7 report panel regressions based on the model

$$ROM_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta \cdot DSP_{it} + \epsilon_{it}, \tag{16}$$

whereas columns (3) and (4) report panel regressions based on the model

$$ROM_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta \cdot \Delta DSP_{it} + \epsilon_{it}, \tag{17}$$

Table 7: Regression of ROM on Specialness

Variable	(1)	(2)	Variable	(3)	(4)
DSP^{GC}	-0.27^{+}		$\Delta\text{DSP}^{\text{GC}}$	-0.48**	
	(-2.05)			(-3.42)	
$\text{DSP}^{\text{LIBOR}}$		-0.27^{+}	$\Delta\text{DSP}^{\text{LIBOR}}$		-0.48**
		(-2.06)			(-3.41)
N	1,409	1,409		1,397	1,397
R^2	0.57	0.57		0.59	0.59

Note: Columns (1) and (2) report panel regressions based on the model

$$ROM_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta \cdot DSP_{it} + \epsilon_{it},$$

while columns (3) and (4) report panel regressions based on the model

$$ROM_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta \cdot \Delta DSP_{it} + \epsilon_{it},$$

where DSP_{it} is either DSP_{it}^{GC} or DSP_{it}^{LIBOR}, ROM_{it} is the month-t return on the mortgage TBA with coupon rate CP_i, and D_i and D_t are coupon dummies and time dummies, respectively. Robust t-statistics are reported in parentheses based on clustered standard errors at the coupon level. 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 2000 to July 2013, with various starting dates that depend on coupon rates.

where DSP_{it} is either DSP_{it}^{GC} or DSP_{it}^{LIBOR}, ROM_{it} is the month-t return on the mortgage TBA with coupon rate CP_i, and D_i and D_t are coupon dummies and time dummies, respectively.

Columns (1) and (2) of Table 7 show that dollar roll specialness levels significantly affect the mortgage returns negatively, regardless of whether the GC repo rate or LIBOR is used to compute specialness. Moreover, using the first-differenced specialness to ease the concern on the time series persistence, we still observe negative impact of specialness on mortgage returns that is highly significant. We conduct further robustness checks on potential misspecifications that affect the OAS differently across both coupons and time, following Gabaix, Krishnamurthy, and Vigneron (2007), and obtain similar results, available upon request.

Overall, the results of this section confirm our hypothesis that dollar roll specialness and MBS returns are negatively related to each other.

7 The Impact of LSAP on Dollar Roll Specialness

In response to the recent financial crisis, the Federal Reserve introduced a sequence of large-scale asset purchase (LSAP) programs of agency MBS, as well as of Treasury securities, for the purpose of "credit easing" (Bernanke (2009)). The first LSAP program of agency MBS was announced in November 2008. The MBS purchases did not start until January 2009, and were finished in March 2010, with a total size of around $1.25 trillion as planed. Then, in September 2011, the Federal Reserve decided to reinvest principal payments from its agency MBS holdings into agency MBS markets, rather than into long-term Treasury securities as it has been doing since August 2010. Finally, in September 2012, another LSAP program of agency MBS began when the Federal Reserve announced that it will purchase additional agency MBS at a pace of $40 billion per month until the labor market and financial market conditions improve substantially. Together with the reinvestments from its agency MBS holdings, the Federal Reserve has been purchasing around $45–55 billion of agency MBS per month from September 2012 till the end of our sample period July 2013.[25] The great majority of these purchases are newly issued 15- and 30-year agency MBS with production coupons, which vary over time with the primary mortgage rate. The Fed's MBS purchases are executed exclusively in the TBA market.

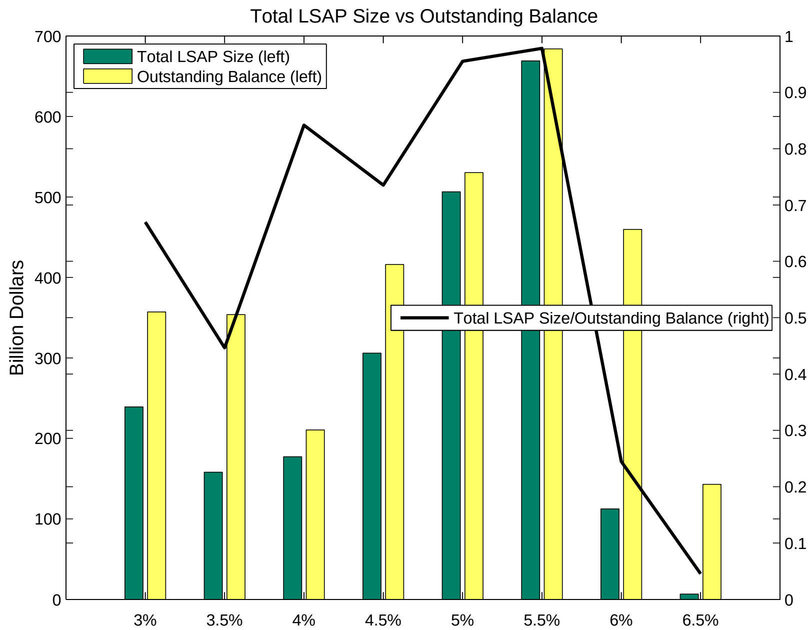
Given the large size of the Federal Reserve's agency MBS purchases, one natural question is whether LSAP "disrupts" the functioning of the agency MBS market. In this section, we investigate this question by studying whether the Federal Reserve's purchases affected dollar roll specialness. We obtain the Federal Reserve's transactions data of the FNMA 30-year MBS with different coupon rates from the website of the Federal Reserve Bank of New York. We also obtain the monthly new issuance (ISU_{it}) as well as the current outstanding balance (CB_{it}) of FNMA 30-year MBS pools across coupon rates, both from the eMBS, to normalize the LSAP size.

Figure 6 plots the aggregate LSAP purchase amount of FNMA 30-year MBS across coupon rates, along with amounts of outstanding balance, from January 2009 to July 2013.[26] We observe that total LSAP size, outstanding balance, and LSAP size as a fraction of

[25]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.

[26]It is worth pointing out that the total purchase size does not take into account the principal payout, and accordingly the outstanding balance in Figure 6 is computed as the sum of the outstanding balance as of December 2008, the last month before the start of LSAP purchases, and the cumulative new issuance between March 2009 and July 2013. Thus, the true outstanding balance may be mildly smaller than that shown.

Figure 6: Size of LSAP



Note: This figure plots cumulative size of LSAP vs outstanding balance of MBS. The sample is from January 2009 to July 2013.

outstanding balance are all hump-shaped in coupon rate. The Fed has absorbed more than 50% of all outstanding balance of FNMA 30-year MBS with coupon rates from 3% to 5.5%. The fraction is over 90% for the 5% and 5.5% coupon cohorts.

We consider five measures for the Federal Reserve's MBS purchases $LSAP_{it}$: the purchase size Q_{it}^{LSAP} (in billions of US dollars), the purchase size as a ratio of the month-t aggregate issuance Q_{it}^{LSAP}/ISU_{it}, the indicator $1(Flow_{it})$ of purchases in month t for coupon CP_i, the cumulative purchase size as a ratio of the month-t outstanding balance $Q_{it}^{Cumulative}/CB_{it}$, and the indicator $1(Stock_{it})$ for the existence of MBS with coupon CP_i in the Federal Reserve's holdings at month t. To align with the monthly specialness measures calculated over the active trading period before the settlement date of each month, we compute Q_{it}^{LSAP} as the aggregate purchase amount in this coupon from the day after settlement of month $t-1$ to two days before the settlement of month t. All other LSAP variables are constructed similarly.

Our investigation is based on the following regression:

$$DSP_{it} = \sum_i \gamma_i D_i + \sum_t \alpha_t D_t + \beta_1 \cdot LSAP_{it} + \beta_2 \cdot SMM_{it} + \beta_3 \cdot NSupply_{it}^{CTD} + \epsilon_{it}, \quad (18)$$

where DSP_{it} is either DSP_{it}^{GC} or DSP_{it}^{LIBOR}. The regressions are estimated for the sample of March 2009–July 2013, which avoids the caveat that including the longer sample before 2009 may mechanically capture the difference of specialness before and after the 2008 financial crisis. We include both coupon and time fixed effects.

Table 8 reports the results of regressions on each of the five LSAP variables, with and without the control variables SMM_{it} and $NSupply_{it}^{CTD}$. Among the five LSAP variables, only Q^{LSAP} and $1(Stock)$ show up significantly, and with a negative sign. For example, the coefficient estimate on the LSAP stock dummy $1(Stock_{it})$ suggests that MBS cohorts that the Fed has purchased in the past have a lower dollar roll specialness by about 150 basis points, relative to MBS cohorts that the Fed has never purchased in the past. The coefficient on Q^{LSAP} suggests that each \$1 billion additional purchase of MBS by the Fed is associated with about 1.4 basis points lower specialness. Overall, there is some evidence that the Fed's purchase is associated with lower dollar roll specialness, although this relation does not show up for some LSAP measures we use.

There are two broad potential hypotheses for the negative relation between the Fed's purchases and dollar roll specialness. The first hypothesis is that the causality runs from high Fed purchases to low specialness. The two channels, adverse selection and liquidity, shed some light on how. On the one hand, because the Fed is likely to be delivered the left tail of CUSIPs that have the worst prepayment characteristics (see Krishnamurthy and Vissing-Jorgensen (2013)), Fed purchases may reduce the heterogeneity of prepayment characteristics among remaining CUSIPs not bought by the Fed. In our analytical framework, a reduction in heterogeneity, represented by a smaller $\mathbb{E}[\max_i \alpha_i] - \mathbb{E}[\alpha_i]$ or $\mathbb{E}[\alpha_i] - \mathbb{E}[\min_i \alpha_i]$ in equation (8), reduces specialness. On the other hand, the Fed's purchases reduce available supply in the market and increase specialness. The result in Table 8 that the inclusion of SMM_{it} and $NSupply_{it}^{CTD}$ reduces the size of the coefficient on LSAP variables suggests the LSAP variables do interact with adverse selection and liquidity and the adverse selection channel dominates.

The second broad hypothesis is that the causality runs from high specialness to low Fed purchase. That is, when purchasing MBS, the Fed concentrates on MBS cohorts with low specialness to avoid "squeezing the market." Moreover, the Fed may also conduct temporary market operations by buying and selling dollar roll contracts to alleviate supply shortage. This hypothesis is in line with Fed communication to the public that the Fed aims to avoid discruptions in the MBS funding market.[27]

To shed some light on the second hypothesis, we examine how the Fed's dollar roll transactions affect specialness, as suggested in the quote at the beginning of the paper. Although the Fed purchases are permanent, the Fed also has discretion of selling dollar roll contracts, which effectively delays taking delivery in LSAP. Such temporary operations alleviate (perceived or real) squeezes in the supply of MBS.

We obtain monthly series of the Federal Reserve's dollar roll sales of the FNMA 30-year MBS with different coupon rates Q_{it}^{Roll} from the website of the Federal Reserve Bank of New York. We consider two measures for the Federal Reserve's dollar roll sales: the size Q_{it}^{Roll} (in billions of US dollars) and the roll size as a ratio of the month-t aggregate issuance Q_{it}^{Roll}/ISU_{it}. These variables are highly correlated with LSAP purchases. Regressing LSAP purchase variables on these dollar roll variables leads to a highly significant and positive coefficient and an R^2 above 70% (results not reported to preserve space). This suggests that the Fed conducts more dollar roll sales on the MBS they purchased more to mitigate the liquidity pressure, consistent with their communications to the public (we hence do not include LSAP purchase and dollar roll variables in the same regressions).

Table 9 reports results on the following regression:

$$DSP_{it} = \sum_i \gamma_i D_i + \sum_t \alpha_t D_t + \beta_1 \cdot FedRoll_{it} + \beta_2 \cdot SMM_{it} + \beta_3 \cdot NSupply_{it}^{CTD} + \epsilon_{it}. \quad (19)$$

For each Fed dollar roll variable, we run regressions both with and without SMM_{it} and $NSupply_{it}^{CTD}$. The results in Table 9 show that a higher volume of the Fed's roll sales is associated with a significantly lower dollar roll specialness, confirming our second hypothesis that the Fed conducts additional operations to mitigate (real or perceived) market squeeze. We also note that the economic magnitude is smaller after controlling for SMM and $NSupply^{CTD}$.

Because we do not have exogenous shocks in the Fed's MBS purchases, all evidence in this section is suggestive rather than definitive. But given the evidence so far, we believe a conservative interpretation of the negative LSAP-specialness relation is the following. The Fed purchases more MBS from cohorts that are less special; simultaneously, the Fed conducts temporary dollar roll sales to delay taking delivery and hence mitigate the supply shortage.

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

Table 8: LSAP and Dollar Roll Specialness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
					DSP^{GC}					
Q^{LSAP}	-1.6775**	-1.3992**								
	(-2.8187)	(-2.8239)								
Q^{LSAP}/ISU			-1.0294	-0.7799						
			(-1.3770)	(-1.2441)						
$1(Flow)$					-65.1601	-53.7304				
					(-1.5978)	(-1.2973)				
$Q^{cumulative}/CB$							-84.2995	-69.4804		
							(-1.5321)	(-1.3634)		
$1(Stock)$									-176.7882**	-149.8910**
									(-10.7261)	(-5.7876)
SMM		5.2361		5.4190*		4.9516*		4.3871*		5.3092*
		(1.6139)		(2.5875)		(2.6252)		(2.4001)		(2.6251)
NSupply$^{\text{CTD}}$		-0.1728*		-0.1880^{+}		-0.1159		-0.1587		-0.1811
		(-2.6366)		(-1.9783)		(-1.0133)		(-1.4492)		(-1.7144)
N	588	577	588	577	588	577	588	577	588	577
R^2	0.8205	0.8211	0.8180	0.8192	0.8229	0.8222	0.8228	0.8225	0.8194	0.8205
					DSP^{LIBOR}					
Q^{LSAP}	-1.6775**	-1.3992**								
	(-2.8187)	(-2.8239)								
Q^{LSAP}/ISU			-1.0294	-0.7799						
			(-1.3770)	(-1.2441)						
$1(Flow)$					-65.1601	-53.7304				
					(-1.5978)	(-1.2973)				
$Q^{cumulative}/CB$							-84.2995	-69.4804		
							(-1.5321)	(-1.3634)		
$1(Stock)$									-176.7882**	-149.8910**
									(-10.7261)	(-5.7876)
SMM		5.2361		5.4190*		4.9516*		4.3871*		5.3092*
		(1.6139)		(2.5875)		(2.6252)		(2.4001)		(2.6251)
NSupply$^{\text{CTD}}$		-0.1728*		-0.1880^{+}		-0.1159		-0.1587		-0.1811
		(-2.6366)		(-1.9783)		(-1.0133)		(-1.4492)		(-1.7144)
N	588	577	588	577	588	577	588	577	588	577
R^2	0.8202	0.8208	0.8178	0.8189	0.8227	0.8218	0.8226	0.8221	0.8192	0.8201

Note: This table reports regressions based on the following model:

$$DSP_{it} = \sum_i \gamma_i D_i + \sum_t \alpha_t D_t + \beta_1 \cdot LSAP_{it} + \beta_2 \cdot SMM_{it} + \beta_3 \cdot NSupply_{it}^{CTD} + \epsilon_{it},$$

where DSP_{it} is either DSP_{it}^{GC} or DSP_{it}^{LIBOR}, and D_i and D_t are the coupon and time dummies. We consider five measures of $LSAP_{it}$, including Q_{it}^{LSAP}, Q_{it}^{LSAP}/ISU_{it}, $1(Flow_{it})$, $Q_{it}^{cumulative}/CB_{it}$, and $1(Stock_{it})$. We report regressions both with and without SMM_{it} and $NSupply_{it}^{CTD}$. Robust t-statistics are reported in parentheses based on clustered standard errors at the coupon level. Significance levels: ** for $p < 0.01$, * for $p < 0.05$, and $^{+}$ for $p < 0.1$, where p is the p-value. The sample period is March 2009-July 2013.

Besides this selection effect, LSAP on average also reduces dollar roll specialness, and the adverse selection channel (reducing specialness) dominates the liquidity channel (increasing specialness).

Table 9: The Fed's Dollar Roll Sales

	DSP^{GC}				DSP^{LIBOR}			
Q^{Roll}	-2.6322*	-2.0489$^+$			-2.6322*	-2.0489$^+$		
	(-2.3156)	(-1.9836)			(-2.3156)	(-1.9836)		
Q^{Roll}/ISU			-1.2242$^+$	-0.7031			-1.2242$^+$	-0.7031
			(-1.7024)	(-1.1575)			(-1.7024)	(-1.1575)
SMM		5.3503		5.3839		5.3503		5.3839
		(1.5654)		(1.5510)		(1.5654)		(1.5510)
NSupply$^{\text{CTD}}$		-0.1862**		-0.2031**		-0.1862**		-0.2031**
		(-2.8140)		(-3.0376)		(-2.8140)		(-3.0376)
N	588	577	588	577	588	577	588	577
R^2	0.8182	0.8194	0.8168	0.8184	0.8180	0.8191	0.8166	0.8181
Coupon Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table reports regressions based on the following model:

$$DSP_{it} = \sum_i \gamma_i D_i + \sum_t \alpha_t D_t + \beta_1 \cdot FedRoll_{it} + \beta_2 \cdot SMM_{it} + \beta_3 \cdot NSupply_{it}^{CTD} + \epsilon_{it},$$

where DSP_{it} is DSP_{it}^{GC} or DSP_{it}^{LIBOR}, and D_i and D_t are the coupon and time dummies. We use two measures of $FedRoll_{it}$, including Q_{it}^{Roll} and Q_{it}^{Roll}/ISU_{it}. We run regressions with and without SMM_{it} and $NSupply_{it}^{CTD}$. Robust t-statistic are reported in parentheses based on clustered standard errors at the coupon level. Significance levels: ** for $p < 0.01$, * for $p < 0.05$, and $^+$ for $p < 0.1$, where p is the p-value. The sample period is January 2009-July 2013, with various starting dates that depend on coupon rates.

8 Additional Results and Robustness Checks

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

8.1 Active coupons and weighted regressions

Our benchmark results in Section 5 use all available TBA coupons. However, some of these may not be very actively traded given that the mortgage rate dropped from about 8% to about 3% over our sample period, as seen in Figure 4. We conduct robustness checks of our main results using both actively traded coupons and weighted regressions in this section. In particular, column (1) of Table 10 reports results of the regression in (9) using the sample of the three coupons with the largest new issuance each month. Columns (2) and (3) report the same regression but weighted by $NSupply^{CTD}$ and monthly new issuance ISU, respectively. We observe that both SMM and $NSupply^{CTD}$ significantly affect the dollar roll specialness as in the benchmark results of Table 4, though the statistical significance of $NSupply^{CTD}$ in the new-issuance weighted regression is weaker. Overall, we find that adverse selection and liquidity remain significant determinants of dollar roll specialness after adjusting for the activeness of different coupons.

8.2 Prepayment risk borne by the dollar roll buyer

Besides redelivery risk, another difference of dollar roll from repo is that the former involves an ownership change of the underlying MBS while the latter does not. That is, the dollar roll buyer owns the MBS collateral and collects the principal and interest payments during the funding period. As a result, the dollar roll buyer will be exposed to prepayment risk, which is naturally expected to affect the dollar roll specialness. In particular, a higher prepayment speed will lead to losses to the dollar roll buyer on a premium MBS (see (2)). Consequently, for premium MBS, the higher is the expected change in prepayment speed, the higher is the financing rate charged by the dollar roll buyer, and the lower is specialness. Conversely, for discount MBS, a lower expected change in prepayment speed leads to a lower specialness.

As a proxy for the expected change in prepayment speed $E_t[SMM_{i,t+1} - SMM_{it}]$, we use its realization $\Delta SMM_{i,t+1} \equiv SMM_{i,t+1} - SMM_{it}$. To consistently link the roll buyer's loss to changes in prepayment speed, we use $\Delta SMM_{i,t+1}$ for premium MBS and $-\Delta SMM_{i,t+1}$ for discount MBS. We run the following panel regression:

$$DSP_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta \cdot (1(Premium) - 1(Discount)) \cdot \Delta SMM_{i,t+1} + \epsilon_{it}, \quad (20)$$

where $1(Premium)$ takes the value of 1 if the MBS is trading at a premium, and zero otherwise; and likewise for $1(Discount)$. Note that the higher $(1(Premium) - 1(Discount)) \cdot$

Table 10: Regression with Active Coupon Buckets and Weighting

DSP^{GC}

	Active Coupons	$\text{NSupply}^{\text{CTD}}$-Weighted Regression	ISU-Weighted Regression
SMM	9.2796^{+}	3.8776^{+}	7.3287^{+}
	(2.0306)	(1.8591)	(2.1487)
$\text{NSupply}^{\text{CTD}}$	-0.2802*	-0.1715**	-0.0597
	(-3.2140)	(-3.2189)	(-1.3712)
N	210	719	470
R^2	0.9284	0.7726	0.8541
Coupon Effect	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes

DSP^{LIBOR}

	Active Coupons	$\text{NSupply}^{\text{CTD}}$-Weighted Regression	ISU-Weighted Regression
SMM	9.2796^{+}	3.8776^{+}	7.3287^{+}
	(2.0306)	(1.8591)	(2.1487)
$\text{NSupply}^{\text{CTD}}$	-0.2802*	-0.1715**	-0.0597
	(-3.2140)	(-3.2189)	(-1.3712)
N	210	719	470
R^2	0.9108	0.7238	0.8007
Coupon Effect	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes

Note: This table reports panel regressions based on the following model:

$$DSP_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta_1 \cdot SMM_{it} + \beta_2 \cdot NSupply_{it}^{CTD} + \epsilon_{it},$$

where DSP_{it} is either DSP_{it}^{GC} or DSP_{it}^{LIBOR}, and D_i and D_t are coupon dummies and time dummies, respectively. The first column reports regressions using the sample of the three coupons with the largest new issuance each month, while the last two columns report weighted regressions based on $NSupply^{CTD}$ and new issuance, respectively. Robust t-statistics are reported in parentheses based on clustered standard errors at the coupon level. 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 2000 to July 2013, with various starting dates that depend on coupon rates.

$\Delta SMM_{i,t+1}$ is, the higher the roll buyer's loss is and hence the lower the specialness is. As a result, the coefficient β is expected to be negative if the roll buyer's exposure to prepayment risk affects dollar roll specialness. Also 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 exposure to prepayment risk. Hence, the fact that the regression has t on the left-hand side and $t+1$ on the right-hand side does not affect the interpretation of the regression.[28]

Table 11 reports the regression results. Columns (1) and (3) report the regression coefficients controlling for coupon but not time fixed effects. There is a negative relation between the prepayment risk borne by the dollar roll buyer and specialness. The negative coefficient is statistically significant only if specialness is measured relative to $LIBOR$. If time fixed effects are also included, the negative coefficients are statistically insignificant. Overall, we find that the prepayment risk borne by the dollar roll buyer only marginally affects specialness with a negative sign on average.

Of course, this prepayment risk borne by the dollar roll buyer may be fierce in unusual circumstances and lead to low and even negative specialness in unusual circumstances. For example, we observe occasional negative specialness in Figure 3, especially in March 2009, when the Fed decided to expand the LSAP program by an additional \$1.05 trillion and when the Home Affordable Refinance Program (HARP) was created by the Federal Housing Finance Agency. Intuitively, the potential lower long-term interest rates caused by the expansion of LSAP program and the creation of HARP lead to large positive shocks to the prepayment rate, which is exactly when the MBS owners want to transfer the prepayment risk to others.

8.3 Credit risk and fails

In this subsection, we consider two additional features in the settlement of TBA contracts that may affect the dollar roll financing rate and specialness: credit risk and fails.

The first is counterparty credit risk. Given that the dollar roll contract spans a horizon of more than a month, the default of one counterparty means that the other counterparty may have to acquire or sell the relevant MBS. Such risks can usually be eliminated or at least mitigated by charging margins. However, only very recently did the market regulators start to 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.[29]

[28]We also have tried $\Delta SMM_{i,t} \equiv SMM_{i,t} - SMM_{i,t-1}$ in the regression and find similar results.

[29]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

Table 11: Prepayment Risk Borne by the Dollar Roll Buyer

	DSP^{GC}		DSP^{LIBOR}	
	(1)	(2)	(3)	(4)
ΔSMM	-1.0849	-0.3033	-1.3292^{+}	-0.3033
	(-1.4880)	(-0.3752)	(-1.9732)	(-0.3752)
N	1,397	1,397	1,397	1,397
R^2	0.3332	0.5791	0.3321	0.5740
Coupon Effect	Yes	Yes	Yes	Yes
Time Effect	No	Yes	No	Yes

Note: This table reports panel regressions based on the following model:

$$DSP_{it} = \sum_t \alpha_t D_t + \sum_i \gamma_i D_i + \beta \cdot (1(Premium) - 1(Discount)) \cdot \Delta SMM_{i,t+1} + \epsilon_{it},$$

where DSP_{it} is either DSP_{it}^{GC} or DSP_{it}^{LIBOR}, and D_i and D_t are coupon dummies and time dummies, respectively. Robust t-statistics are reported in parentheses based on clustered standard errors at the coupon level. 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 2000 to July 2013, with various starting dates that depend on coupon rates.

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 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 negatively affects the IFR because this credit risk makes roll sellers less willing to lend MBS unless they receive a favorable (low) financing rate.

The second is failure to deliver at settlement, i.e., the security borrower in a dollar roll transaction delays 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

debt, and agency MBS markets.

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.[30] Therefore, we expect the amount of failure to deliver is negatively associated with the IFR.

Though we expect credit risk and failure to deliver to affect the dollar roll financing rates negatively, we expect neither to affect dollar roll specialness significantly. This is because GC repo rates should be affected by credit risk and failure to deliver in a similar fashion as dollar roll financing rates are.

To investigate how credit risk and failure to deliver affect the 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 and the amount of delivery fails in agency MBS transactions by U.S. Primary Dealers from the website of the Federal Reserve Bank of New York.[31] 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. The failure-to-deliver data are at the weekly frequency from January 2013 to July 2013, and we construct monthly time series taking the first week of each month.

Panels A and B of Table 12 reports panel regressions based on

$$X_{it} = \sum_i \gamma_i D_i + \beta \cdot JPM_t^{cds} + \epsilon_{it}, \tag{21}$$

and

$$X_{it} = \sum_i \gamma_i D_i + \beta \cdot Fail_t + \epsilon_{it}, \tag{22}$$

[30] 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 (see Figure 3). 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.

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

respectively, where X_{it} is IFR_{it}, DSP_{it}^{GC}, or DSP_{it}^{LIBOR}. Note that we do not include time dummies as both JPM_t^{cds} and $Fail_t$ are pure time-series variables.[32] 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 four columns of Panel A imply that specialness is not significantly affected by credit risk, although the point estimates are all negative; that is, the effect of credit risk on dollar rolls is not statistically different from that on GC repos. Furthermore, results in the first row of Panel B show that a larger volume of settlement fails is associated with statistically significant lower dollar roll financing rates, but it has no effect on 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 (22) with the post-February 2012 subsample. The second row of Panel B shows that specialness does not respond 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.

9 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 tool that the Federal Reserve uses in conducting its monetary policy. A dollar roll is effectively a secured lending contract, but different from a repo contract, the cash lender who receives an MBS as collateral in a dollar roll transaction has the option to return a different MBS when the loan matures. Dollar roll specialness is defined as the extent to which implied dollar roll financing rates fall below prevailing market interest rates. Therefore, specialness is a key indicator of the funding markets of agency MBS.

In this paper, we provide the first analysis of the economics of mortgage dollar roll specialness. Our analytic framework highlights two important determinants of dollar roll specialness: adverse selection that is unique to MBS markets and liquidity that is generic in OTC markets. Using two proprietary data sets from January 2000 to July 2013, we show that dollar roll specialness increases in adverse selection (proxied by the single monthly mortality

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

Table 12: Credit Risk and Settlement Fails

	IFR		DSP^{GC}		DSP^{LIBOR}	
A: Credit Risk						
	(1)	(2)	(3)	(4)	(5)	(6)
JPM^{cds}	-2.1418**	-2.6279**	-0.7475	-0.4260	-0.7301	-0.4266
	(-4.0346)	(-6.6873)	(-1.4263)	(-1.0026)	(-1.3931)	(-1.0128)
N	1,034	1,034	1,034	1,034	1,034	1,034
R^2	0.5165	0.1984	0.5420	0.0104	0.5417	0.0106
Coupon Effect	Yes	No	Yes	No	Yes	No
Time Effect	No	No	No	No	No	No
B: Settlement Fails						
	IFR		DSP^{GC}		DSP^{LIBOR}	
	(1)	(2)	(3)	(4)	(5)	(6)
Fail (All Sample)	-0.6109**		-0.0516		-0.0689	
	(-5.5462)		(-0.6007)		(-0.8036)	
Fail (Sample with Fails Charge)		-0.2066		0.2304		0.1977
		(-1.0025)		(1.1181)		(0.9595)
N	1,348	156	1,348	156	1,348	156
R^2	0.4002	0.9490	0.3140	0.9486	0.3143	0.9489
Coupon Effect	Yes	Yes	Yes	Yes	Yes	Yes
Time Effect	No	No	No	No	No	No

Note: This table reports panel regressions based on the following models:

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

and

$$X_{it} = \sum_i \gamma_i D_i + \beta \cdot Fail_t + \epsilon_{it},$$

where X_{it} is IFR_{it}, DSP_{it}^{GC}, or DSP_{it}^{LIBOR}, and D_i is the coupon dummy. In Panel B, the fist row reports regression coefficients using all the sample, while the second row reports regression coefficients using the post-February 2012 sample with the fails charge. Robust t-statistics are reported in parentheses based on clustered standard errors at the coupon level. 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 2000 to July 2013, with various starting dates that depend on coupon rates.

rate) and decreases in MBS liquidity (proxied by the net supply of the CTD cohort). We also show that expected returns of the underlying MBS decreases in their specialness. These results are consistent with our analytic framework and robust to various model specifications.

Applying this framework we evaluate the impact of the Federal Reserve's MBS purchase program on MBS financing markets since the 2008 financial crisis. Our results document a significant negative LSAP-specialness relation, implying that the large size of MBS absorbed by the Fed does not result in (detectable) market distortions. Although this negative relation should be cautiously interpreted as correlation than causality, we offer evidence that LSAP does interact with adverse selection and liquidity in MBS markets, and that the Fed conducts temporary dollar roll sales to alleviate (real or perceived) squeezes in MBS markets by delaying taking delivery of purchased MBS.

Appendix: a Worked Example of Dollar Roll

In this appendix we present a worked example for the calculation of dollar roll financing rates in Table 13, corresponding to the dollar roll transaction of Figure 2 (see Hayre (2001) and Hayre and Young (2004) 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 13. 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.[33] 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.[34] 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

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

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 redelivery premium, search costs, and other frictions in the market.

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

[34] 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 13: 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.

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