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Abstract

Agency mortgage-backed securities (MBS) issued by Fannie Mae and Freddie Mac have historically traded in separate forward markets. We study the consequences of this fragmentation, showing that market liquidity endogenously concentrated in Fannie Mae MBS, leading to higher issuance and trading volume, lower transaction costs, higher security prices, and a lower primary market cost of capital for Fannie Mae. We then analyze a change in market design—the Single Security Initiative—which consolidated Fannie Mae and Freddie Mac MBS trading into a single market in June 2019. We find that consolidation increased the liquidity and prices of Freddie Mac MBS without measurably reducing liquidity for Fannie Mae; this was in part achieved by aligning characteristics of the underlying MBS pools issued by the two agencies. Prices partially converged prior to the consolidation event, in anticipation of future liquidity. Consolidation increased Freddie Mac's fee income by enabling it to remove discounts that previously compensated loan sellers for lower liquidity.

Key words: MBS, TBA, Single Security Initiative, UMBS, liquidity

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1 Introduction

Fragmentation is a pervasive feature of financial markets. For example, stock trading is fragmented into various exchanges, electronic communication networks, and alternative trading systems. Fragmentation is even more prevalent for fixed-income securities traded over-the-counter (OTC) with dealers intermediating trades bilaterally (e.g., Treasuries, mortgage-backed securities, corporate bonds, and interest rate and credit derivatives). Theories show that fragmentation can reduce liquidity through the loss of "thick market" externalities (Mendelson (1987), Pagano (1989), and Chowdhry and Nanda (1991)) but in other cases can improve market quality by fostering competition (Economides (1996)). Many empirical studies have investigated the effects of market fragmentation, but have focused on equity markets almost exclusively.[1]

In this paper, we study the economic consequences of fragmentation in one of the largest fixed-income markets in the world, the agency mortgage backed securities (MBS) market dominated by the government sponsored enterprises (GSEs) Fannie Mae and Freddie Mac.[2] MBS trading is concentrated in the "To-Be-Announced" (TBA) forward market, in which any one of many bonds can be delivered at settlement. But until recently, MBS issued by the two GSEs traded separately in this market and were not fungible with one another. We study the effects of this fragmentation, and then analyze a recent change in market structure — the "Single Security Initiative" — which consolidated Fannie Mae and Freddie Mac MBS into a single market in June 2019.

We first present evidence that agency MBS market activity has historically been highly concentrated in the Fannie Mae segment of the market. In panel regressions, we find that Fannie MBS trading volume is on average about ten times larger than Freddie Mac prior to the Single Security Initiative, either unconditionally or controlling for prepayment characteristics, and about seven times larger scaled by the outstanding stock of MBS. We also use TRACE data to construct three measures of transaction costs widely

[1] For example: see Battalio (1997), Boehmer and Boehmer (2003), Amihud, Lauterbach, and Mendelson (2003), Hendershott and Jones (2005), Bennett and Wei (2006), Foucault and Menkveld (2008), O'Hara and Ye (2011) among others.

[2] There is $8.4 trillion in outstanding agency MBS as of the fourth quarter of 2020. This is smaller than $21.0 trillion of Treasury securities, but comparable to $10.6 trillion of corporate bonds and higher than $3.9 and $1.5 trillion of municipal bonds and asset-backed securities respectively. Around 90% of agency MBS is backed by 1-4 family residential mortgages; the remainder is mainly backed by mortgages on apartment buildings and other multifamily properties. Source for statistics: Securities Industry and Financial Markets Association (SIFMA).

used in studies of OTC markets, the round-trip transaction cost (Bessembinder, Maxwell, and Venkataraman, 2013), the Roll (1984) measure, and the Amihud (2002) measure. We find higher transaction costs for Freddie Mac TBAs based on all three measures; quantitatively trading costs are up to twice as high, depending on the measure used.

Theories of endogenous market concentration (e.g., Vayanos and Weill (2008), Weill (2008)) imply that higher market liquidity is priced in the form of a liquidity premium. We find evidence for such a premium, with Fannie MBS priced higher by about 17 cents per $100 face value on average over 1998-2016, controlling for a flexible set of interaction terms to account for the effects of differences in payment timing on security value. We also study option-adjusted spreads (OAS), a model-based estimate of expected return after accounting for prepayment risk, finding that the Fannie Mae price premium translates into a 4 basis point (bp) lower OAS.[3]

These differences in trading volume, issuance and prices vary over time and in the cross-section of TBA cohorts. We find some evidence that the Fannie Mae liquidity premium is increasing with the Baa-Aaa corporate bond spread and agency debt-Treasury yield spread, two measures of bond risk premia. Further, the Fannie Mae price premium and trading volume advantage is also larger for less liquid cohorts trading at a high premium to par, suggesting that the effects of Fannie Mae liquidity pooling are stronger when overall liquidity is lower. We also find however that there is a Fannie Mae liquidity premium across the coupon stack, including MBS cohorts trading at par or at a discount, suggesting that our results are not a result of non-interest-rate prepayment risk or a failure to properly control for Freddie Mac's slightly faster average prepayment speeds.[4]

These differences in liquidity translate into a lower rate of return on mortgage securitization for Freddie Mac. In response to lower TBA liquidity, Freddie Mac discounted its guarantee fees to remain competitive with Fannie Mae—we document based on data from 10-K filings that Freddie Mac net guarantee fees are consistently 5-10 bp lower than Fannie Mae prior to the Single Security Initiative. Goodman and Ranieri (2014) estimate that these discounts have cost Freddie Mac as much as $1bn annually, a cost ultimately borne by taxpayers during the period of the GSEs public conservatorships. In some sense

[3]Related work using OAS for MBS valuation includes Gabaix, Krishnamurthy, and Vigneron (2007), Boyarchenko, Fuster, and Lucca (2019), and Song and Zhu (2019).

[4]Because prepayments are received at par by the MBS investor, faster prepayment reduces the fundamental value of an MBS pool trading at a premium but increases the value of a pool trading at a discount. An MBS pool trading trading at par is not exposed to prepayment risk, at least locally (see Boyarchenko, Fuster, and Lucca (2019) and Gabaix, Krishnamurthy, and Vigneron (2007) for more details).

this figure is an measure of the aggregate cost of the loss of network externalities due to market fragmentation.[5]

In the second half of the paper we then study the Single Security Initiative, a landmark shift in the structure of the agency MBS market which greatly reduced market fragmentation by making Fannie Mae and Freddie Mac MBS fungible with one another in the TBA market. Under this new market structure, Fannie Mae and Freddie Mac MBS are issued using a standardized and uniform design called "Uniform" MBS (UMBS), and TBA sellers can deliver MBS issued by either agency, or a combination, when a trade is settled. The new UMBS were first issued in June 2019, with TBA forward trading beginning three months earlier in March. We take advantage of this market reform to study how market consolidation affects liquidity and pricing. The five-year period from announcement to implementation provides an appealing setting to study whether price and liquidity adjust on a forward-looking basis in anticipation of future liquidity, consistent with dynamic models of liquidity (Amihud and Mendelson (1986), Huang (2003), Vayanos (1998)).

We first study how the Fannie Mae-Freddie Mac gap in trading volume, issuance, and prices adjusts during the transition period leading up to the culmination of the Single Security Initiative in mid-2019. We indeed do find evidence of convergence during this transition period: the trading volume of Freddie Mac TBAs increases relative to Fannie Mae by up to 20%, while the OAS gap declines by up to 7 basis points. Furthermore we present suggestive evidence that these changes are not a zero sum game but instead reflect an improvement in overall market quality, by using Ginnie Mae TBAs (which were not part of the Single Security Initiative) as a comparison group. We find that Freddie Mac prices and trading volume increase relative to Ginnie Mae, but there is no measurable deterioration for Fannie Mae. Using the same approach we also find no robust evidence of significant negative liquidity effects after UMBS are first issued in mid-2019, when the Fannie-Freddie liquidity gap entirely disappears by design.

The convergence in liquidity and prices between Fannie Mae and Freddie Mac also leads to a convergence in the cost of securitization financing between the two agencies. Specifically, the pre-UMBS difference in net guarantee fee income essentially disappears after the completion of the Single Security Initiative, as Freddie Mac is able to remove price discounts previously used to compensate loan sellers for lower liquidity.

[5]For theories of market concentration and fragmentation with network externalities see Mendelson (1987), Pagano (1989), Chowdhry and Nanda (1991), and Economides (1996)).

A key concern of market participants was that UMBS would lead to an "unravelling" effect due to greater heterogeneity and adverse selection within each TBA cohort (in line with the model of (Li and Song, 2020)). we find evidence that steps taken by the GSEs and their regulator helped reduce heterogeneity in security design and characteristics during the UMBS transition period. This homogenization likely contributed to the apparent success of the Single Security Initiative and the absence of obvious unravelling effects. Indeed, we find that the difference in prepayment speeds between Fannie Mae and Freddie Mac MBS declined as UMBS implementation approached, and the average difference was less than 1 percentage point over 2014-2019.

Related literature. This paper most directly contributes to the literature on financial market structure and market fragmentation. Theoretical studies include Mendelson (1987), Pagano (1989), Chowdhry and Nanda (1991) Vayanos and Wang (2007), Vayanos and Weill (2008), Weill (2008), Hendershott and Mendelson (2000), Chao, Yao, and Ye (2018), Babus and Parlatore (2019), Li and Song (2020), Chen and Duffie (2021), and Allen and Wittwer (2021) among others. Most of these studies focus on an environment with one asset traded at multiple potential venues, except Li and Song (2020) who consider heterogeneous assets. Empirical studies of fragmentation mostly focus on the equity market within the framework of one asset being traded at multiple venues, including Amihud, Lauterbach, and Mendelson (2003), O'Hara and Ye (2011), Foucault and Menkveld (2008), Bennett and Wei (2006), Barclay and Hendershott (2004), and Barclay, Hendershott, and Jones (2008) among others.

Our paper contributes to the empirical studies of market fragmentation by studying a large over-the-counter debt market — OTC markets are arguably more fragmented than exchange-traded markets because trading is bilateral and decentralized. Our study also emphasizes the role of asset heterogeneity, a key feature of OTC-traded fixed-income markets, and tests the theoretical proposition that asset heterogeneity can reduce liquidity by making the distribution of asset values within an MBS cohort more diffuse (Vickery and Wright (2011), Bessembinder, Spatt, and Venkataraman (2019) and Li and Song (2020)). This mechanism is distinct from the usual focus on decreased competition as the primary negative consequence of market centralization. Finally, we trace through the effects of agency MBS fragmentation not just on secondary market trading but also MBS issuance in the primary market and the issuer's rate of return on security issuance.[6] These effects

[6]Related to these results, Huh and Kim (2019) study the effect of TBA eligibility on the primary mortgage

of market fragmentation on primary markets have not been previously analyzed, to the best of our knowledge.

We also contribute to an expanding body of research on agency MBS market microstructure and asset pricing. Microstructure studies include Vickery and Wright (2011), Bessembinder, Maxwell, and Venkataraman (2013), Downing, Jaffee, and Wallace (2009), Friewald, Jankowitsch, and Subrahmanyam (2017), Gao, Schultz, and Song (2017), Gao, Schultz, and Song (2018), Schultz and Song (2019), and Huh and Kim (2020). Asset pricing studies focus on valuation of the prepayment option embedded in fixed-rate mortgages (examples include Levin and Davidson, 2005; Boyarchenko, Fuster, and Lucca, 2019; Chernov, Dunn, and Longstaff, 2018; Gabaix, Krishnamurthy, and Vigneron, 2007; Diep, Eisfeldt, and Richardson, 2017), although a smaller number of papers also study liquidity effects (Krishnamurthy and Vissing-Jorgensen (2013), Fusari, Li, Liu, and Song (2019), and He and Song (2020)). This paper contributes at the intersection of the microstructure and asset pricing literatures, showing how institutional factors shape market liquidity and liquidity premia.

2 Institutional Background

2.1 The Agency MBS Market

Agency MBS are mortgage bonds guaranteed by the government sponsored enterprises (GSEs) Fannie Mae and Freddie Mac or the government agency Ginnie Mae.[7] The agency MBS market finances 62% of U.S. home mortgage debt as of 2019, and is one of the largest and most active fixed income markets in the world, with more than $200bn in average daily trading volume (sources: SIFMA; Urban Institute Housing Finance Chartbook).

Agency MBS are traded over-the-counter, either through a specified pool trade where counterparties transact a particular security, or a to-be-announced (TBA) forward trade

rate, while An, Li, and Song (2021) study how the existence of parallel TBA and specified pool trading affects the way mortgages are packaged into MBS.

[7] Fannie Mae and Freddie Mac are private but government-sponsored corporations which are currently in public conservatorship. Ginnie Mae is a government agency within the Department of Housing and Urban Development which provides investor guarantees on MBS backed by federally insured mortgages. For more background on Fannie Mae and Freddie Mac see Acharya, Richardson, Nieuwerburgh, and Wright (2011) or Frame, Fuster, Tracy, and Vickery (2015).

where any MBS within an eligible set can be delivered to the buyer.[8] That is, a TBA trade specifies a cohort, defined by the agency, maturity, and coupon (e.g., FNMA 30 year MBS with 3.5% coupon), and the price is set without specifying which MBS from the cohort will be delivered at settlement.[9]

At any given time, there are tens of thousands of MBS outstanding, each with different characteristics in terms of loan amounts, geography, credit scores and so on. Consequently there is substantial heterogeneity in prepayment risk and fundamental value.[10] The TBA market effectively concentrates this large MBS universe into a few dozen contracts for trading purposes, thereby improving fungibility and liquidity (Li and Song (2020)). The TBA market is significantly more active than the specified pool market, accounting for more than 90% of agency MBS trading volume. See Hayre (2001), Vickery and Wright (2011), and Gao, Schultz, and Song (2017) for more institutional details.

2.2 Liquidity Differentials and the Single Security Initiative

Agency MBS issued by Fannie Mae and Freddie Mac have very similar fundamental characteristics. But as we document in Section 5.1, Fannie Mae TBA trading volume persistently outpaced Freddie Mac prior to the culmination of the Single Security Initiative, often by an order of magnitude or more.

How did this liquidity gap develop and why did Fannie Mae become the thick market? Fannie Mae has an incumbency and size advantage because it is older than Freddie Mac and always purchased a larger volume of mortgages than its competitor, even though it relied relatively less on securitization for funding during the 1970s and early 1980s (see Appendix A for historical details). But this does not account for the magni-

[8] All TBA-eligible MBS are so-called "pass-through" securities, which pay mortgage principal and interest net of servicing and guarantee fees proportionately to all investors. Structured MBS which tranche cash flows to create bonds with different prepayment and maturity profiles are not eligible for TBA delivery. Some pass-through MBS are also not TBA-eligible (e.g., "high-balance" pools where more than 10% of loan balances are mortgages with principal exceeding the national conforming loan limit.)

[9] The MBS to be delivered are specified two days before settlement. Unlike most forward contracts, TBA contracts have only one settlement date per month set by SIFMA (e.g., for 30-year Fannie Mae MBS, settlement day is typically around the 12th or 13th of the month). The detailed TBA settlement schedule is available at https://www.sifma.org/resources/general/mbs-notification-and-settlement-dates/. TBA trading occurs for settlement up to three months in the future.

[10] Prepayment risk arises because agency MBS are backed by long-term (usually 30-year) fixed-rate mortgages which can be freely prepaid at par. An unexpected increase in prepayment reduces the value of MBS trading at a premium but increases the value of MBS trading at a discount.

tude of the gap in trading volume. Our interpretation is that Fannie Mae's natural scale advantage was amplified by a self-reinforcing thick market effect: participants preferred trading in Fannie Mae TBAs because of the larger market size and better historical liquidity, further reinforcing Fannie Mae's liquidity advantage, analogous to the "on-the-run" phenomenon in the Treasury market (Vayanos and Weill, 2008; Pasquariello and Vega, 2009; Krishnamurthy, 2002).

This liquidity gap put Freddie Mac at a competitive disadvantage, since Freddie Mac was often forced to discount its guarantee fees to mortgage sellers to compensate for the lower liquidity of its MBS, a practice known as market adjusted pricing (FHFA, 2015). Motivated by the disparity in liquidity, the Federal Housing Finance Agency (FHFA) proposed the idea of unifying Fannie Mae and Freddie Mac TBAs into a single security in its 2012 Strategic Plan for Enterprise Conservatorships (FHFA, 2012). At the same time the FHFA announced an initiative to construct a Common Securitization Platform to replace Fannie Mae and Freddie Mac's separate proprietary systems, which among other benefits would help pave the way towards a single security.[11]

The FHFA emphasized its commitment to a single security in its 2014 strategic plan, and on August 12th, 2014, it issued a Request for Input (FHFA (2014)) which proposed a design for the single security and sought public feedback. The final design was announced on July 11, 2016. The GSEs began securitizing agency MBS on the Common Securitization Platform on November 21, 2016 (known as "Release 1" of the platform), and preparations continued for the single security, to be known as Uniform MBS (UMBS). On March 18 2018, the FHFA announced that issuance of UMBS on the Common Securitization Platform would begin in June 2019 (known as "Release 2" of the platform). Issuance of UMBS ultimately began on June 3rd 2019.[12]

Since this date, all TBA-eligible MBS issued by Fannie Mae or Freddie Mac are issued as UMBS and are traded through a single set of UMBS TBA contracts where eligible MBS from either agency can be delivered at settlement. The design of UMBS mimics Fannie Mae's legacy securities, and all existing Fannie Mae pools were automatically converted to UMBS on the June 3 implementation day. Legacy Freddie Mac pools can be exchanged

[11] The proposed platform was intended to be sufficiently flexible to allow new agency MBS issuers to enter the market and to potentially outlast Fannie Mae and Freddie Mac, depending on the outcome of GSE reform. As well as facilitating competition, transitioning to a single platform was also thought to maximize economies of scale and enhance MBS uniformity and liquidity.

[12] Because MBS can be traded on the TBA market up to three months before issuance, UMBS forward trading began on March 4th 2019.

for UMBS with compensation provided to the investor for differences in payment timing.[13] UMBS disclosure rules generally follow those previously set by Freddie Mac.

3 Economic Framework and Hypotheses

In this section, we frame our empirical analysis in the context of the theoretical literature on endogenous market concentration and fragmentation, including Mendelson (1982, 1985), Pagano (1989), Chowdhry and Nanda (1991), Vayanos and Wang (2007), Vayanos and Weill (2008), and Weill (2008) on assets with a single fundamental value and Li and Song (2020) on assets with heterogeneous fundamental values.

While the mechanics of these models differ, a consensus prediction is that trading will endogenously concentrate in a particular market because of network externalities, or as often summarized, "liquidity begets liquidity". Most models are silent as to which market will become the focal venue for trading, and the answer will be indeterminate if different trading venues are assumed to be identical ex ante. However it seems plausible that thick market externalities would tend to amplify any slight ex-ante advantage of one market vis a vis another, causing it to become the dominant venue for trading. In the context of the TBA market, Fannie Mae had an ex-ante incumbency advantage, as discussed in Section 2.2, consistent with the fct that TBA trading became concentrated in the Fannie Mae segment of the market.

Existing models focus on secondary market liquidity and do not typically make predictions about primary market issuance. We conjecture however that a more general framework with endogenous primary market issuance would generate feedback effects that further concentrate trading: greater liquidity would support higher primary market issuance, leading to higher activity and liquidity in the thick market.

We summarize these predictions in the following hypothesis.

Hypothesis 1 *Prior to UMBS, both primary and secondary market liquidity is concentrated in Fannie Mae MBS, specifically in the form of (i) higher TBA trading volume, (ii) lower transaction costs, and (iii) higher primary market issuance.*

[13] UMBS pools have a 55 day delay between the scheduled mortgage payment date and the payment of cash flow to investors, rather than the 45 day delay used for legacy Freddie Mac pools. Thus, Freddie Mac investors need to be compensated for this additional delay given a positive time value of money.

The asset pricing literature also predicts higher prices in the more liquid market (Amihud and Mendelson, 1986; Vayanos and Wang, 2007), implying that Freddie Mac MBS would be priced at a relative discount, holding fundamental value fixed. Our empirical analysis attempts to quantify such price discounts using a number of approaches to separate liquidity effects from other determinants of security value. We also test for differences in guarantee fees, in light of the general understanding among practitioners that Freddie Mac sometimes reduced its fees to compensate loan sellers for the lower value of its less liquid securities. These tests are summarized in the following hypothesis:

Hypothesis 2 *Prior to UMBS, Fannie Mae TBAs have higher prices conditional on fundamental value, and Fannie Mae sets higher average guarantee fees.*

Further, we posit that the Fannie Mae TBA liquidity premium may vary over time and in the cross-section depending on the overall value of liquidity. In particular we test whether it is higher when aggregate liquidity is low and risk premia are high, for instance in periods where dealers and other financial intermediaries have low risk-bearing capacity (He and Krishnamurthy, 2018).[14] The liquidity premium may also be amplified when risk premia on agency debt securities specifically are elevated, reflecting a flight-to-liquidity phenomenon among agency MBS investors, and feedback effects between market liquidity and risk premia (He and Xiong, 2012; Beber, Brandt, and Kavajecz, 2008). In the cross-section, the premium may also be magnified for thinly-traded TBA contracts where overall liquidity is low.

Hypothesis 3 *The Fannie Mae TBA liquidity premium increases with the overall value of liquidity. In particular:*

(i.) The premium rises when market-makers are constrained and bond risk premia are high

(ii.) The premium is larger for illiquid TBA coupons

Next we consider the effects of the consolidation of Fannie Mae and Freddie Mac trading into a single set of UMBS forward contracts. By construction, consolidation results in full convergence in TBA trading volume and price. But it is less clear *when* this convergence would be expected to occur. In dynamic models of market liquidity, market prices

[14] Boyarchenko, Fuster, and Lucca (2019) find evidence of co-movement in bond spreads between the agency MBS market and corporate bond market, even though agency MBS are not credit sensitive, which they interpret as being due to the presence of common marginal investors between the two markets.

and trading decisions today reflect investors' expected holding period as well as expectations about *future* prices and liquidity (Amihud and Mendelson (1986), Huang (2003), Vayanos (1998)). Consequently, we expect prices and trading volume between Fannie Mae and Freddie Mac to at least partially converge in advance of the UMBS implementation date, reflecting anticipation of future liquidity convergence.

Hypothesis 4 *Fannie Mae and Freddie Mac TBA prices and liquidity partially converge prior to UMBS implementation, in anticipation of future liquidity conditions.*

Although the goal of UMBS is to enhance liquidity, particularly for Freddie Mac MBS but also to some extent for Fannie Mae, critics argued it could actually have the opposite effect. In the agency MBS market, less-valuable pools with unattractive prepayment characteristics trade on a fungible basis in the TBA market while high-value pools trade individually in the specified pool market. As shown by Li and Song (2020), market consolidation in such a market could reduce liquidity by enlarging asset heterogeneity, particularly since Freddie Mac MBS pools historically had somewhat faster prepayment speeds relative to Fannie Mae, typically reducing their value. Introducing these lower-value MBS into the cohort of deliverable bonds could lower TBA prices and drive many higher-value MBS to migrate to trading in the specified pool market, thereby actually reducing TBA liquidity.

Such "unravelling" would particularly affect Fannie Mae TBA liquidity, because this market segment was previously the most liquid, and because Fannie Mae pools historically had slightly more favorable prepayment characteristics on average. Higher asset heterogeneity could also increase the basis risk between TBA prices and the fair value of MBS held by investors, making TBAs less valuable as a hedging instrument.

Cognizant of these concerns, the Single Security Initiative included several steps to align the security design and prepayment characteristics of Fannie Mae and Freddie Mac pools, with the goal of improving uniformity and preventing the "unravelling" effects described above. In our empirical analysis (see Section 6) we examine whether these steps were successful in homogenizing the two sets of assets, and as a result, whether the new set of UMBS contracts became at least as liquid as the Fannie Mae TBAs that they replaced. In summary:

Hypothesis 5 *(i) The transition to UMBS does not diminish TBA market liquidity for Fannie Mae; (ii) UMBS implementation leads to convergence in prepayment characteristics between*

Fannie Mae and Freddie Mac MBS.

Finally we test whether UMBS implementation reduces the gap in guarantee fees between the two GSEs by allowing Freddie Mac to curtail their practice of discounting fees to compensate for the lower liquidity of their securities.

Hypothesis 6 *UMBS implementation leads to a convergence in guarantee fees between Fannie Mae and Freddie Mac.*

4 Data

We study the effect of MBS market fragmentation and subsequent consolidation on a range of outcomes including trading activity, primary market issuance, and asset prices. We rely on three main data sources: (1) eMBS, which is used to measure MBS issuance and outstanding volume as well as security characteristics such as TBA eligibility; (2) the supervisory version of the Trade Reporting And Compliance Engine (TRACE) dataset, which is used to construct agency MBS trading volume and liquidity metrics[15]; (3) J.P. Morgan Markets., which is used to extract data on MBS prices, option-adjusted spreads, prepayment forecasts and some other financial time-series.

More details of the data construction are provided below:

TBA trading volume: We generally measure trading volume at a monthly frequency, focusing on front-month TBA contracts for 30-year Fannie Mae, Freddie Mac and Ginnie Mae MBS. We are able to construct these series from May 2011 onwards, when TRACE began collecting data on agency MBS trading.

Agency MBS outstanding and issuance: We measure primary market activity based on the monthly new issuance and outstanding balance for 30-year Fannie Mae, Freddie Mac and Ginnie Mae MBS. These series are constructed by aggregating eMBS security-level data. For our analysis of these outcome variables we focus on the sample period from January 1998 onwards, matching the availability of price and OAS data from J.P. Morgan Markets.

[15]The main advantages of the supervisory version of TRACE are that it does not top-code trade sizes, and includes individual dealer identifiers.

Price and OAS: We utilize monthly TBA price and OAS data for 30-year Fannie Mae, Freddie Mac and Ginnie Mae MBS. These series are available from January 1998 onwards.[16] As described in Gabaix, Krishnamurthy, and Vigneron (2007) and Boyarchenko, Fuster, and Lucca (2019), among others, the OAS is a constant interest rate spread added to the term structure of interest rates such that the present value of the expected future cash flows of an MBS (averaged across different interest rate paths and taking into account prepayment along each path) equals the market price of the security. We mainly use OAS series based on the Libor term structure, but also use Treasury OAS in robustness tests. In constructing monthly series, we use the OAS on the final business day of the month. In keeping with our analysis of trading volume, we focus on OAS for front-month settlement.

These series (trading volume, issuance, outstanding, price, and OAS) are all available at the coupon cohort level. Agency MBS are typically issued with coupons in increments of 50 basis points (bps). At any point in time, usually six to eight coupon cohorts are actively traded in the TBA market for each agency and maturity. The set of coupons which are actively traded moves over time with the level of interest rates, since new production of MBS will be concentrated in coupons with prices relatively close to par.

Similar to Diep, Eisfeldt, and Richardson (2017), we index each coupon cohort in terms of its moneyness, defined as the difference between the cohort note rate and the "current coupon", which is the note rate for a synthetic TBA contract trading exactly at par.[17] For example if the Fannie Mae current coupon is 2.86%, the 2.5% TBA contract would have an index value of CC-1, the 3% TBA contract with index value CC+1, the 3.5% contract with an index value of CC+2 and so on.[18] To ensure that we focus on actively traded cohorts, we limit the sample to coupon cohorts with moneyness values between CC-2 and CC+6.

Guarantee Fees: We collect quarterly data on guarantee fees from Fannie Mae and Freddie Mac's 10-Q and 10-K filings. These filings report average guarantee fees on the agency's entire portfolio, as well as guarantee fees on new purchases in the quarter. These

[16] These TBA prices, as well as the OAS based on them, are based on trades intermediated by J.P. Morgan. As a major MBS dealer, J.P. Morgan collected data on prices well before FINRA began collecting transaction data via TRACE in May 2011. Over the period since TRACE is available, J.P. Morgan prices closely correspond to TRACE prices.

[17] The current coupon yield is a model-based calculation interpolated from cohorts trading just above and below par. We obtain current coupon yields from J.P. Morgan Markets.

[18] As argued by Diep, Eisfeldt, and Richardson (2017), when conducting time-series analysis for individual TBA contracts it is more natural to group contracts together based on moneyness (e.g., group all CC+1 observations together, rather than all 3% TBA contract values together).

reported fees reflect both periodic and up-front guarantee fees. Up-front fees are amortized over the expected life of the mortgage. Fees are reported on an annualized basis.

MBS characteristics: We use eMBS to obtain monthly realized prepayment rates and other security characteristics of 30-year Fannie and Freddie MBS traded in the TBA market. These variables are used to control for differences in prepayment risk profiles. We also make use of Conditional Prepayment Rate (CPR) forecasts from J.P. Morgan Markets, which are based on J.P. Morgan's estimate of the actual set of pools likely to be delivered into TBA contracts.

Yield spreads: Time-series financial data such as corporate bond yields, Treasury and agency debt yields are drawn from the St. Louis Fed FRED database.

Table 1 reports monthly averages of (i) MBS trading volume, (ii) MBS issuance, (iii) outstanding balance, (iv) price (per $100 of principal), and (v) OAS (in basis points) for each moneyness cohort. Volume, balance and issuance are summed across Fannie Mae and Freddie Mac and price and OAS are reported as the average across the two agencies.

The sample is an unbalanced panel, with a higher number of observations for cohorts trading near par, which are the coupons into which new security production is typically issued. Average monthly new issuance ranges from $12-$16 billion for CC-1 to CC+2, around $5-$6 billion for the CC-2 and CC+3 cohorts, with little issuance for the CC+4 cohorts and above. The relative variation in outstanding balance across cohorts is much smaller though, since the stock of MBS reflects securities issued at different points in time over a range of interest rate environments. TBA trading volume is highest in the coupons just above par, although there is active trading across almost the entire coupon stack.

As expected, the average TBA price increases with moneyness, with values ranging from $96-$110 per $100 face value. Average OAS varies between 15-31 basis points, with higher values for the coupons further from par reflecting the OAS "smile" studied in Boyarchenko, Fuster, and Lucca (2019).

Table 1: **Summary Statistics**

	Trading Volume ($bil)	Issuance ($bil)	Unpaid Balance ($bil)	Price (% of par)	Libor OAS (bp)
CC-2					
Mean	29.51	5.68	182.85	95.53	20.76
N	43	165	232	206	205
CC-1					
Mean	119.37	12.2	359.68	98.7	17.81
N	75	219	244	226	225
CC+1					
Mean	271.02	15.79	434.64	101.31	15.15
N	91	250	253	235	235
CC+2					
Mean	336.94	14.55	413.87	103.47	18.07
N	93	249	250	215	215
CC+3					
Mean	184.43	5.39	356.11	105.26	21.94
N	94	239	240	191	191
CC+4					
Mean	66.78	1.3	236.88	106.98	26.43
N	94	211	236	161	161
CC+5					
Mean	25.19	.27	151.7	108.78	28.38
N	93	131	215	131	131
CC+6					
Mean	12.04	.12	98.04	110.16	30.67
N	83	54	191	122	122

Note: Monthly time series mean of 30-year MBS trading volume, issuance, unpaid principal balance outstanding, price (per $100 of principal), and Libor OAS (in basis points) for each moneyness cohort, aggregated across Fannie Mae and Freddie Mac. We restrict the sample to CC-2 to CC+6 to ensure that cohorts are reasonably liquid. Sample periods: May 2011 to February 2019 for trading volume, January 1998 to February 2019 for issuance, unpaid balance, price, and Libor OAS. Trading data are for front-month settlement TBA contracts. Source: Trading volume data are from FINRA TRACE, issuance and unpaid balance data are from eMBS, price and Libor OAS data are from J.P. Morgan DataQuery.

5 Liquidity and Price Effects of Market Fragmentation

This section studies the consequences of the market fragmentation that existed prior to UMBS, focusing on the period up to June 2016.[19] In the analysis presented below we find that MBS trading is highly concentrated in Fannie Mae TBAs during this period, that Fannie Mae TBAs have lower transaction costs, and that Freddie Mac securities trade at a discount to Fannie Mae after accounting for differences in fundamental value. Fannie Mae also has higher primary market issuance, and its share of the MBS primary market relative to Freddie Mac grows over time. Although the dominance of Fannie Mae in secondary MBS market trading was known to market participants and discussed anecdotally in policy discussions, our analysis is to our knowledge the first detailed academic study of these effects.

5.1 Primary Issuance and Secondary Market Trading Volume

First, we study whether Fannie Mae TBAs have higher trading volume and primary market issuance, as formulated in Hypothesis 1.

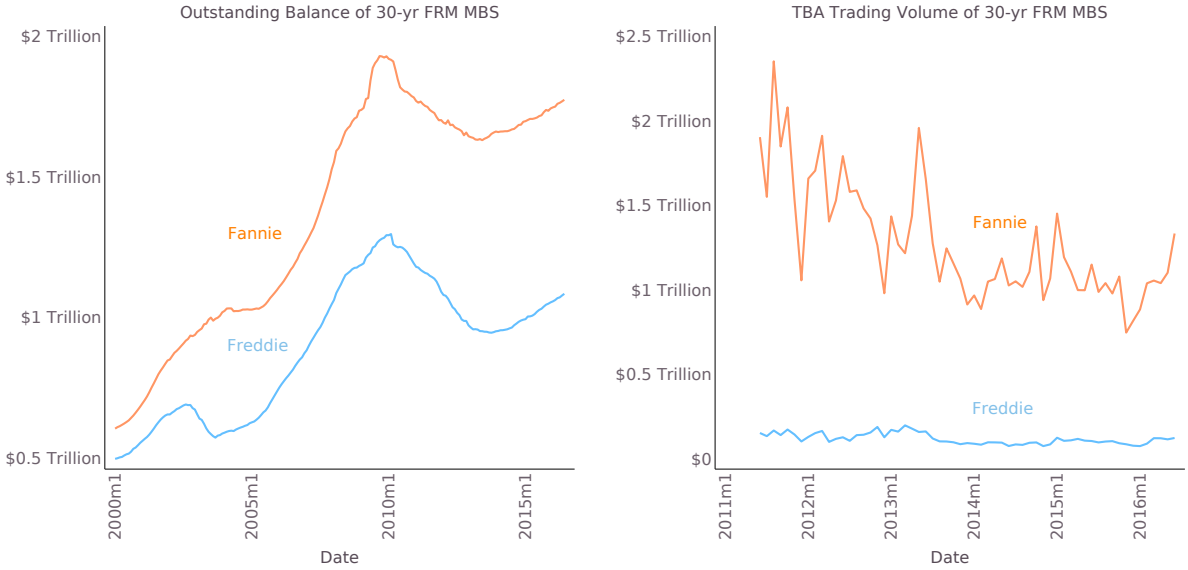
Graphical evidence is presented in Figure 1.[20] Fannie Mae has a larger outstanding volume of TBA-eligible MBS throughout the sample period (left panel), but the gap between the two GSEs widens over time both in absolute and proportionate terms. The right panel plots total monthly TBA trading volume for front-month settlement, summing across all coupons but excluding dollar rolls (Song and Zhu (2019)). Trading activity fluctuates over time but TBA volume for Fannie Mae is consistently an order of magnitude larger than for Freddie Mac.

Table 2 quantifies the average difference in trading volume and primary market issuance. Columns 1-3 are based on aggregate data summing over different cohorts, while columns 4-6 are based on pooled cohort-level data. The table reports the average log-difference between Fannie Mae and Freddie Mac as well as the ratio of the two (computed as the exponent of the log difference). Consistent with Figure 1, trading volume is much

[19] We focus on this cutoff point because on July 7, 2016 the FHFA published a significant document which set a firm timetable and milestones for the single security initiative and finalized several important aspects of UMBS design (FHFA, 2016). The main results presented below are not particularly sensitive to the endpoint chosen, however, as we show subsequently.

[20] The figure is restricted to 30 year fixed rate mortgage pools, which make up a large majority of agency MBS and TBA trading.

Figure 1: **Outstanding Balance & TBA Trading Volume**



Note: MBS unpaid principal balance (UPB) outstanding and trading volume for TBA-eligible Fannie Mae and Freddie Mac 30-year fixed-rate passthrough MBS pools. Sample periods: January 2000 to June 2016 for the left panel and June 2011 to June 2016 for the right panel. TBA trading volume data are for front-month settlement TBA trades excluding dollar rolls, stip trades, and non-standard TBA contracts. Source: Unpaid balance data are from eMBS and trading volume data are from FINRA TRACE.

larger for Fannie Mae, not just in absolute terms (10.9 times larger) but also relative to the volume of securities outstanding (6.5 times larger). In other words, the difference in trading volume is much larger than the difference in the stock of TBA-eligible MBS. Further, primary market issuance of TBA-eligible MBS is about 50 percent higher for Fannie Mae, consistent with the widening gap in the stock of MBS between the two GSEs. These differences are even larger based on the pooled data, implying that the differences are more pronounced for coupons with smaller volume and/or issuance.

5.2 Secondary Market Transaction Costs

Next we test whether concentration of trading in the Fannie Mae segment of the TBA market leads to lower transaction costs, as also proposed in Hypothesis 1. Using TRACE data we construct three measures of transaction costs widely used in studies of OTC market

Table 2: **Fannie Mae–Freddie Mac Gap in Issuance & Trading Volume**

	Trading volume	Issuance	Trading vol/UPB	Trading volume	Issuance	Trading vol/UPB
Log difference: (Fannie Mae – Freddie Mac)	2.39*** (0.04)	0.41*** (0.02)	1.88*** (0.04)	2.65*** (0.04)	0.75*** (0.04)	1.98*** (0.05)
Implied ratio	10.91	1.51	6.55	14.15	2.12	7.24
Sample Mean	2.39	0.41	1.88	2.65	0.75	1.98
Observations	62	222	62	434	1323	434
Sample	Aggregate	Aggregate	Aggregate	Pooled Cohort	Pooled Cohort	Pooled Cohort

Note: Average difference in log of trading volume and MBS issuance between Fannie Mae and Freddie Mac, based on aggregated & pooled coupon-level data. Sample Period: May 2011 to June 2016 for volume and balance data, and January 1998 to June 2016 for issuance data. We restrict the sample to CC-2 to CC+6 for pooled regressions to remove cohorts with de minimus trading and/or UPB; we do not impose this restriction on the aggregate time series regressions. Trading volume data are for front-month settlement TBAs. Source: Trading volume data are from FINRA TRACE. Issuance and unpaid balance data are from eMBS. Implemented by linear regression on a constant term. HAC robust standard errors in parentheses. Errors are clustered by month. Significant at *p<0.10, **p<0.05, ***p<0.01.

microstructure, the round-trip transaction cost (Bessembinder, Maxwell, and Venkataraman, 2013), the Roll (1984) measure, and the Amihud (2002) measure. In a simplified sense, the first two measures capture the bid-ask spread (in percentage terms), while the last captures the market depth (in percentage price change per million dollar trade). Details on the construction of these measures are provided in Appendix B. For each liquidity measure we construct a daily time series of transaction costs for each Fannie Mae and Freddie Mac TBA coupon for front-month settlement.

Table 3 reports results from a pooled regression in which we regress each liquidity measure on a Freddie Mac dummy, controlling for five return variables as used in Gao, Schultz, and Song (2017).[21] Regressions also include fixed effects for either the TBA

[21] These include daily returns of the (1) Barclays Capital's U.S. MBS index, (2) Barclays Capital's 7- to 10-Year U.S. Treasury Bond index, (3) Barclays Capital's U.S. Corporate Bond Index, (4) Barclays Capital's U.S. Corporate High-Yield Bond Index, and (5) the SP 500 index.

coupon or the coupon moneyness, to account for differences in trading costs across the coupon stack.

Table 3: **Liquidity Gap: Evidence from Transaction-Cost Liquidity Measures**

	Round-trip transaction cost		Roll bid-ask impact measure		Amihud price measure	
Freddie Mac	0.013***	0.011***	0.020***	0.020***	0.099***	0.093***
	(0.002)	(0.002)	(0.004)	(0.004)	(0.007)	(0.008)
Controls:						
MBS return	1.932*	2.176**	0.095	-0.008	9.029*	9.653*
	(1.028)	(1.064)	(2.015)	(1.980)	(5.341)	(5.466)
Treasury return	-0.678	-0.722	0.197	0.331	-2.721	-2.709
	(0.727)	(0.737)	(1.575)	(1.561)	(3.213)	(3.311)
Aaa return	0.543	0.526	-0.753	-0.851	0.298	0.072
	(0.605)	(0.619)	(1.297)	(1.298)	(2.939)	(2.993)
High-yield return	-0.036	0.019	0.395	0.445	-1.557	-1.661
	(0.327)	(0.328)	(0.624)	(0.625)	(1.420)	(1.427)
S&P 500 return	0.079	0.079	0.240	0.224	-0.083	-0.099
	(0.093)	(0.092)	(0.249)	(0.249)	(0.561)	(0.564)
Sample Mean	0.022	0.022	0.133	0.133	0.081	0.081
Observations	12,950	12,950	11,168	11,168	13,962	13,962
Coupon FE	Yes	No	Yes	No	Yes	No
Cohort FE	No	Yes	No	Yes	No	Yes

Note: Regressions of the Bessembinder, Maxwell, and Venkataraman (2013) round-trip transaction cost, the Roll (1984) measure, and the Amihud (2002) measure on a Freddie Mac TBA dummy, controlling for five time series variables of index returns and coupon-level fixed effects. Sample period: June 2011 to June 2016. Daily series by coupon for front settlement months for each agency, based on transaction-level data on TBA trades. We restrict the sample to CC-2 to CC+6 to ensure that cohorts are reasonably liquid. Source: FINRA TRACE. HAC robust standard errors in parentheses. Significant at *p<0.10, **p<0.05, ***p<0.01.

Transaction costs are higher for Freddie Mac TBAs based on all three measures. Quantitatively, the difference in trading costs is 1.1-1.3 basis points (bps) for the round-trip transaction cost measure and 2.0 bps for the Roll measure, while based on the Amihud measure, a $1 million trade moves the price of Freddie Mac MBS by around 9.3-9.9 bps more than the price of Fannie Mae MBS. Comparing these estimates to the sample averages of the three liquidity measures, the estimates imply that trading costs for Freddie

Mac TBAs are at least 15 percent higher than for Fannie Mae, and more than twice as high based on the Amihud measure.[22] Transaction costs are still low in absolute terms in the Freddie Mac segment, but these differences are quantitatively important considering that TBA trading volume exceeds $200bn per day on average.

5.3 Price Differences

Next we test whether there is a liquidity premium which raises Fannie Mae TBA prices relative to Freddie Mac, as formulated in Hypothesis 2. To isolate this liquidity premium, we must control for differences in fundamental value, which reflect two factors: (i) bonds issued by the two agencies have different prepayment characteristics; in particular Freddie Mac pools historically prepaid slightly faster than Fannie Mae on average, reducing their effective duration and compressing their prices towards par; (ii) prior to UMBS, Freddie Mac pools paid principal and interest to investors with a 45-day payment delay, compared to 55 days for Fannie Mae, raising the relative fair value of Freddie Mac pools, simply due to a positive time value of money.

We use two different approaches to strip out these differences in fundamental value and isolate the liquidity premium. In the first approach, we adjust Fannie Mae prices by an estimate of the fair value of the timing difference reported to us by market participants of 2/32nds of a percentage point[23], and then saturate the regressions with cohort $\times$ prepayment speed differential interaction effects.[24] In the second approach, we examine differences in OAS, which as discussed earlier provide a model-based estimate

[22] This is quantitatively comparable to the difference in issuance, but much lower than the difference in trading volume (as reported in Table 3). There are at least two reasons for the differential magnitudes. First, trading cost is determined by both liquidity supply and demand. Although the concentration in Fannie Mae TBAs makes liquidity supply in Freddie Mac TBAs low, as low trading volume reflects, liquidity demand may be low as well. Second, take the difference in trading cost as given and assume that an investor needs to execute a very large MBS trade. Such an investor would find the total trading cost substantially larger in Freddie Mac MBS than Fannie Mae MBS, even with a small difference in average cost, and hence prefer trading in Fannie Mae TBAs.

[23] TBAs are traded in increments of a "tick", equal to 1/32nd of a percent. This two-tick adjustment is an approximation, since the fair market value of the 10-day difference in payment timing depends on the asset duration and the level of interest rates. As a result we likely slightly understate the estimated liquidity premium associated with Fannie Mae TBAs in the earlier part of the sample when the level of interest rates was higher than it is today.

[24] For agency MBS trading at a premium, faster prepayment reduces price because prepayments are received at par by the investor. The converse is true for MBS trading at a discount. We capture this nonlinearity in the price and OAS regressions by controlling for $I_i(moneyness = i) \times \text{CPR difference}_{it}$, allowing the coefficient on the difference in prepayment speed to vary completely flexibly across moneyness cohorts.

of differences in yield that account for differences in prepayment behavior (based on a prepayment model) as well as differences in payment timing.[25]

Table 4 reports average differences in price and OAS between Fannie Mae and Freddie Mac using monthly coupon-level data from 1998 to 2016. Over the full sample, the average price gap is +17 cents per $100 par value after accounting for the difference in prepayment speed and payment timing. The estimated OAS difference is -3.9bp over the full sample; in other words Fannie Mae TBAs trade at lower yields, consistent with their higher prices. The price and OAS estimates are of roughly consistent magnitudes given that 30 year fixed-rate agency pools have an average option-adjusted duration on the order of 4 years.

Interestingly, the price and OAS differential is substantially larger during and after the 2008 financial crisis than in the period prior to the crisis. This may reflect a reduction in the ability of dealers to provide liquidity due to balance sheet constraints and heightened post-crisis regulation (in line with evidence in Adrian, Boyarchenko, and Shachar (2017) and other work).

5.4 Guarantee Fees

Finally, we trace through the effects of the Fannie Mae TBA liquidity premium on the rate of return to securitization, or put differently, the cost of capital of financing agency mortgages through securitization. We measure this rate of return by studying the relative guarantee fees charged by the two GSEs. Fannie Mae and Freddie Mac compete for the business of large originators seeking to swap whole loans into agency MBS. But as a result of lower MBS liquidity, Freddie Mac was often forced to discount their guarantee fees in order to remain competitive with Fannie Mae, a practice known as market adjusted pricing.[26,27]

[25] We have confirmed with J.P. Morgan that their OAS estimates during this period account for the 10-day payment timing differential between Fannie Mae and Freddie Mac.

[26] From FHFA (2015): *"Fannie Mae's MBS tend to trade at higher prices (with corresponding lower interest rate yields) than similar securities from Freddie Mac. This is mainly due to the liquidity benefit of a larger volume of Fannie Mae securities in the market. Freddie Mac is able to compete with Fannie Mae for business by offering market adjusted pricing (MAP) to its lenders that exchange loans for MBS. MAP provides a discount from the contractual ongoing guarantee fee based on the spreads between Fannie Mae and Freddie Mac MBS."*

[27] Smaller originators instead generally securitize conforming mortgages through the "cash window", by swapping them with the GSEs for cash rather than MBS. In this case, the illiquidity discount will instead result in a lower gain on sale earned by Freddie Mac from buying whole loans and selling the resulting

Table 4: **Differences in Price & Option-Adjusted Spread (OAS)**

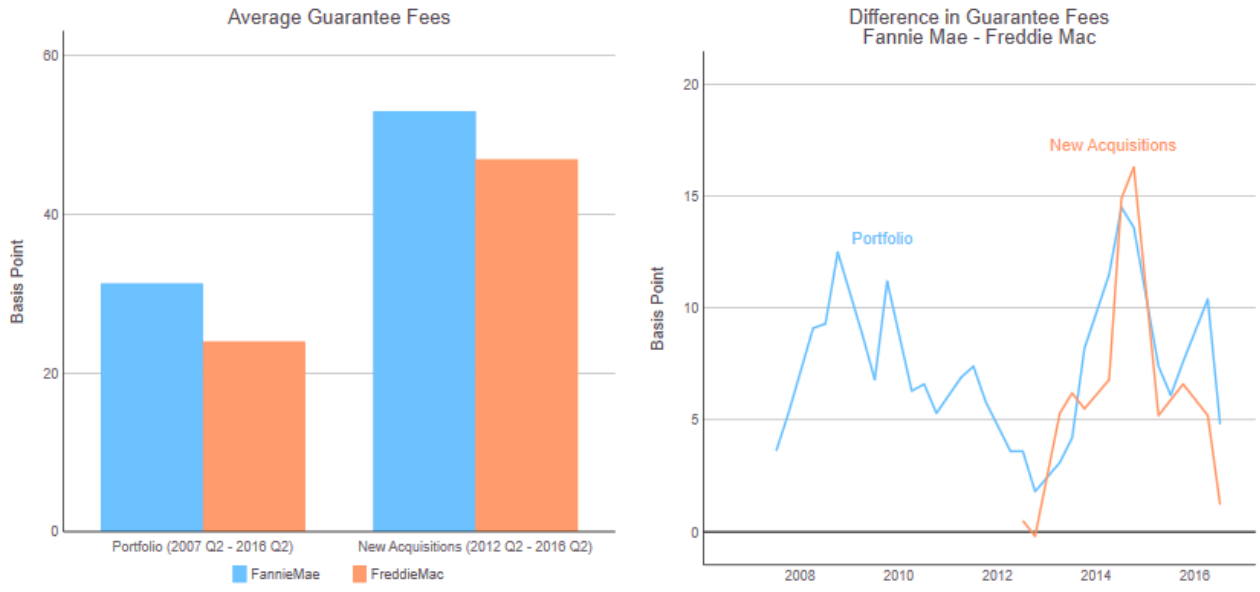
Average difference: Fannie Mae – Freddie Mac			
	(1) Price Gap (% of par)	(2) Libor OAS Gap (bp)	(3) Obs
Full Sample [Jan 1998 to June 2016]	0.17*** (0.029)	-3.90*** (0.38)	1232
Pre-Crisis [Jan 1998 to July 2007]	0.041** (0.013)	-2.32*** (0.20)	458
Crisis [Aug 2007 to Dec 2011]	0.36*** (0.064)	-6.59*** (0.93)	365
Post-Crisis [January 2012 to June 2016]	0.28*** (0.059)	-4.74*** (0.71)	409
Sample Mean (Full Sample)	0.20	-5.12	
Cohort FE	X	X	
Cohort x CPR Diff Interaction	X	X	

Note: Average Fannie Mae-Freddie Mac difference in price and Libor OAS. Price gap is adjusted for the difference in payment delay between the two GSEs. Pooled sample of TBA contracts across coupons and time. Monthly observations. Sample Period: January 1998 to June 2016. We restrict the sample to CC-2 to CC+6 to ensure that cohorts are reasonably liquid. Data are for front-month settlement TBA contracts. Libor OAS gap is winsorized at the 1% level. Source: J.P. Morgan DataQuery. HAC robust standard errors in parentheses. Errors are clustered by date. Significant at *p<0.10, **p<0.05, ***p<0.01.

Figure 2 presents evidence on the magnitude of these discounts based on average guarantee fees charged by the two GSEs, collected from 10-Q and 10-K filings. Freddie Mac net guarantee fees are consistently 5-10 bp lower than Fannie Mae, both on new acquisitions and their entire portfolios. To put this difference in context, in 2016, just prior to UMBS implementation, Freddie Mac had just over $1.5tr in single-family agency MBS outstanding. A 5bp illiquidity discount in annual fee income on this entire balance amounts to $750m per annum in forgone fee income. This simple calculation is consistent with Goodman and Ranieri (2014), who estimate that market adjusted pricing has cost Freddie Mac as much as $1bn annually, a cost ultimately borne by taxpayers in the period since the GSEs entered public conservatorship in 2008.

MBS, rather than a discounted guarantee fee.

Figure 2: **Annual Guarantee Fees of Fannie Mae vs Freddie Mac**



Note: Annual net guarantee fees charged by Fannie Mae and Freddie Mac, collected from 10-Q filings. Numbers are inclusive of market adjusted pricing discounts offered by Freddie Mac. Source: Fannie Mae and Freddie Mac.

The lower fee income earned by Freddie Mac as a result of market-adjusted pricing can be viewed as an estimate of the aggregate cost of the fragmented pre-UMBS structure of the agency MBS market. These fee discounts put Freddie Mac at a competitive disadvantage, consistent with the gradual erosion of Freddie Mac's market share of agency MBS securitization documented earlier. Furthermore, looking prospectively, one goal of GSE reform as articulated by the FHFA is to facilitate greater competition in the agency MBS market. The liquidity advantage enjoyed by Fannie Mae prior to the implementation of UMBS represented a significant hurdle to such competition, because any potential new entrant would be shackled by an illiquidity discount in the agency MBS market at least as large as the one faced by Freddie Mac.

5.5 Variation in the Fannie Mae liquidity premium

5.5.1 Time-series variation

Next we study time-series variation in the Fannie Mae TBA liquidity premium, and in particular examine whether this premium increases with corporate bond risk premia and the risk premium on agency debt (Hypothesis 3). Following Boyarchenko, Fuster, and Lucca (2019), we use the Baa–Aaa corporate bond spread to measure the credit risk premium in the bond market, and the agency debt–Treasury yield spread to measure the risk premium on agency debt.

Table 5 presents pooled coupon-level regressions of the Fannie Mae–Freddie Mac gap in price (in Panel A) and OAS (in Panel B) on the Baa–Aaa and agency debt spread, as well as aggregate mortgage prepayment speeds (measured by analyst projections of the Fannie Mae conditional prepayment rate, CPR) as a measure of prepayment risk. The first three columns include each variable one at a time while Column (4) includes all variables together. As in our earlier price and OAS specifications, all regressions include moneyness cohort fixed effects as well as moneyness dummies interacted with the cohort-level prepayment speed difference between Fannie Mae and Freddie Mac.

We find some evidence that the Fannie Mae TBA liquidity premium is increasing in the measures of bond risk premia. In univariate regressions, the Baa–Aaa spread and agency debt spread are both positively related to the Fannie Mae – Freddie Mac price differentials and negatively related to the OAS differential. Three of the four coefficients are statistically significant (the price coefficient on the Baa–Aaa spread is not). The two spreads are not individually significant in the multivariate regressions in column (4), reflecting collinearity between the two measures.

5.5.2 Variation across the coupon stack

Next, we study cross-sectional variation across the coupon stack. A first question of interest is whether there is still a price and OAS gap even for coupons trading at or near par. This would imply that our findings are unlikely to be driven by prepayment risk, which does not materially affect the value of a MBS at par (Boyarchenko, Fuster, and Lucca, 2019). Closely related, evidence of a price and OAS gap for both premium and discount bonds would imply that the gap is not due to the faster average prepayment speed

Table 5: **Time Series Variation of Fannie–Freddie Gap in Price & OAS**

A: Adjusted Price Gap (% of par)				
	(1)	(2)	(3)	(4)
Fannie 3M CPR	-0.0632***			-0.0382*
	(0.0212)			(0.0198)
Baa-Aaa Spread		0.0162		-0.0159
		(0.0114)		(0.0132)
FNMA Debt - Swap Spread			0.0667***	0.0705***
			(0.0133)	(0.0140)
Mean of dep. var.	.1986	.1986	.2086	.2086
Cohort Fixed Effects	X	X	X	X
Cohort x CPR Diff Interaction	X	X	X	X
Observations	1232	1232	1176	1176
B: Libor OAS (bp)				
	(1)	(2)	(3)	(4)
Fannie 3M CPR	0.5655			0.3117
	(0.6495)			(0.6664)
Baa-Aaa Spread		-0.5276**		-0.3652
		(0.2393)		(0.2743)
FNMA Debt - Swap Spread			-0.5234**	-0.3060
			(0.2517)	(0.2942)
Mean of dep. var.	-5.129	-5.129	-5.301	-5.301
Cohort Fixed Effects	X	X	X	X
Cohort x CPR Diff Interaction	X	X	X	X
Observations	1232	1232	1176	1176

Note: Panel regressions of Fannie Mae-Freddie Mac price and Libor OAS gaps on standardized Fannie Mae 3-month projected CPR by cohort, Baa-Aaa spread, and Fannie Mae agency debt spread (on-the-run 5yr agency yield minus 5yr swap rate). Sample Period: January 1998 to June 2016. We restrict the sample to CC-2 to CC+6 to ensure that cohorts are reasonably liquid. Agency MBS price and OAS data are for front-month TBA settlement. Libor OAS is winsorized at the 1% level. Source: J.P. Morgan DataQuery. HAC robust standard errors in parentheses, clustered by month. Significant at *p<0.10, **p<0.05, ***p<0.01.

of Freddie Mac pools, because faster prepayment will *increase* the price of a TBA cohort trading at a discount to par. Furthermore, we investigate whether the Fannie Mae trading volume and liquidity premium is amplified for less liquid coupons trading at large discounts or premiums, as proposed in Hypothesis 3. (As Table 1 shows, TBA trading is generally concentrated in production coupons close to par.)

Figure 3 reports the price and OAS differential between Fannie Mae and Freddie Mac by TBA coupon conditional on a zero difference in cohort CPR.[28] We report these estimates for the entire period 1998-2016, and also over three subperiods: before, during, and after the financial crisis and associated Great Recession. We observe a larger gap in price and OAS for cohorts which are further in-the-money. For example, the average gap in OAS increases by about 7 bps from the CC+1 to the CC+4 TBA cohort, and by another 10 bps to CC+6 bps. These patterns are consistent with the view that the greater liquidity of Fannie Mae TBAs is more highly valued in the in-the-money cohorts which overall are more illiquid, consistent with Hypothesis 3.

Furthermore, we find an economically significant difference in price and OAS for TBA coupons close to par, as well as those that are out-of-the-money. As discussed above, this alleviates concerns that our earlier results are an artifact of non-interest-rate prepayment risk not captured by OAS or our moneyness $\times$ prepayment differential interaction terms, or the failure to properly control for differences in prepyament speeds. Instead, these results suggest the price and OAS differences do indeed reflect a liquidity premium for Fannie Mae TBAs.

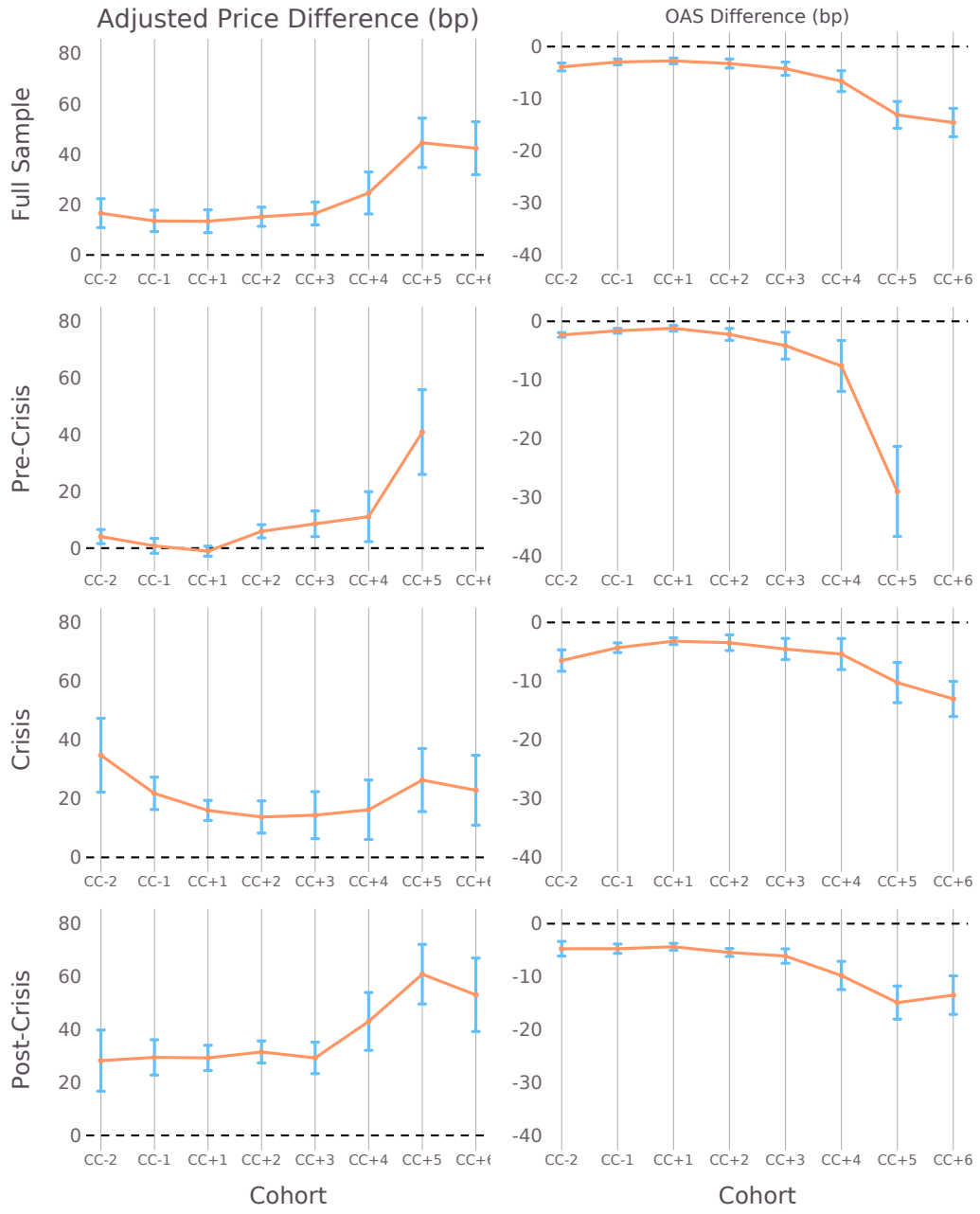
Figure 4 also reports estimates of differences in log trading volume and log issuance by TBA coupon (indexed by moneyness).[29] The log-difference in trading volume is quite flat across the coupon stack (Figure 4.A), but scaled by outstanding balance, the trading volume differential is larger for coupons that are further in-the-money, where we have shown above that the price difference is also larger. Panel B also suggests that Freddie Mac MBS issuance is more heavily concentrated in the coupon just above par, where its liquidity disadvantage is relatively smaller.[30]

[28] In line with our earlier regressions, the graph reports the constant term from a coupon-level regression of the Fannie Mae vs Freddie Mac price or OAS difference on the cohort-level CPR difference.

[29] The point estimates and confidence bounds are constructed by regressing the log difference in the relevant variable on a constant term, using standard errors that are adjusted for autocorrelation.

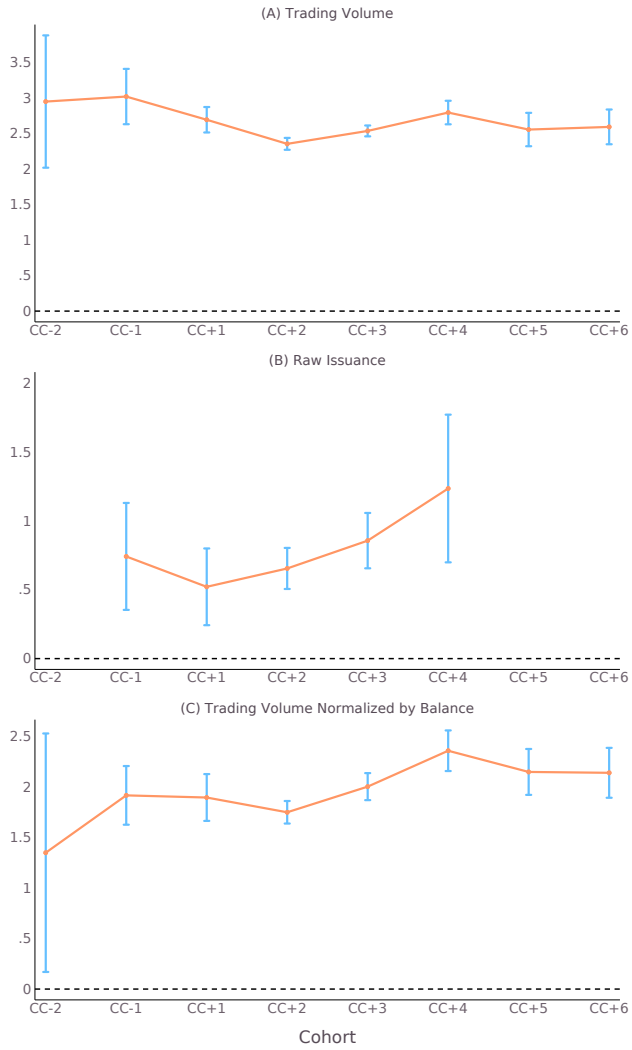
[30] As shown previously in Table 1, new MBS issuance or "production" is highly concentrated in coupons near the current coupon: CC-1, CC+1 and CC+2.

Figure 3: **Fannie–Freddie Gap in Price & Libor OAS Across Coupon Cohorts**



Note: Constant coefficients from panel regressions of the Fannie Mae-Freddie Mac adjusted price difference (left) and Libor OAS difference (right) on CPR difference. We restrict the sample to CC-2 to CC+6 to ensure that cohorts are reasonably liquid. Sample Periods: January 1998 to June 2016 for Full Sample; January 1998 to July 2007 for Pre-Crisis; Aug 2008 to Dec 2011 for Crisis; January 2012 to June 2016 for Post-Crisis. Data are for front-month settling MBS. Libor OAS is winsorized at the 1% level. Source: J.P. Morgan DataQuery. HAC robust standard errors shown.

Figure 4: **Gap in Issuance & Trading Volume by Moneyness**
Log difference [Fannie Mae - Freddie Mac]



Note: Constant coefficients from panel regressions of Fannie Mae - Freddie Mac differences in log(Volume), log(Issuance), and log(Volume/Balance) by TBA coupon indexed by moneyness relative to the current coupon (e.g. CC-1 means the TBA coupon immediately below the current coupon). Computed via a regression on CPR difference with HAC robust standard errors. We restrict the sample to CC-2 to CC+6 to ensure that cohorts are reasonably liquid. For issuance, we restrict the sample to CC-1 to CC+4 since there is little new issuance outside this range. Sample period: May 2011 to June 2016. Data are for front-month settling MBS. Source: Volume data are from FINRA TRACE and issuance/balance data are from eMBS.

6 Effects of Market Consolidation

We now analyze the effects of the market consolidation of Fannie Mae and Freddie Mac TBAs into a single set of UMBS forward contracts. We first study the evolution of liquidity in the transition period leading up to UMBS forward trading, and then examine subsequent changes in market conditions post-UMBS implementation.

6.1 Convergence between Fannie Mae and Freddie Mac

To study the period leading up to UMBS implementation, we estimate time series regressions of the Fannie Mae–Freddie Mac gap in trading volume, issuance, and price on a set of pre-implementation time dummies (one for each year after the basic design of UMBS is settled in June 2016), controlling for the gap in prepayment speed interacted with moneyness and other time series variables (e.g., Baa-Aaa and agency debt spreads) as previously used in Table 5. Coefficients on the time dummies trace out any changes in the Fannie Mae–Freddie Mac liquidity gap in anticipation of market consolidation. The "pre" period in these regressions is the twelve months leading up to June 2016.

Results are presented in Table 6. Looking at the first two columns, the Fannie–Freddie gap in trading volume (in both raw amount and normalized amount by outstanding balance) is lower in each of the three 12-month periods after June 2016 than in the pre-period. The difference is statistically significant in two of the three periods. The gap in trading volume declines by as much as 20%, although the dummies fluctuate over time indicating that other factors are also at play. There is no statistically significant change in relative issuance volume.

Columns 3 and 4 report results for price and OAS, and are estimated at the coupon $\times$ month $\times$ GSE level like our earlier analysis. Here we find an economically large and statistically significant degree of convergence between Fannie Mae and Freddie Mac prior to UMBS implementation. The point estimates become larger over time, indicating greater convergence as the UMBS implementation date approaches, with a maximum effect size in the year prior to UMBS implementation of 6.6bp for OAS and 34bp of par for price.

These results imply that the market prices of Fannie Mae and Freddie Mac bonds converged mainly due to expectations about *future* liquidity conditions. Even though Fannie Mae trading volume remains far higher than Freddie Mac until the two sets of

Table 6: **Convergence prior to UMBS Implementation**

	Trading Volume and Issuance			Adjusted Price and OAS	
	Log (Volume)	Log (Volume/Balance)	Log (Issuance)	Adjusted Price Gap (% of par)	Libor OAS (bp)
Time dummies:					
2016/07 to 2017/06	-0.23***	-0.19***	-0.04	-0.21***	4.39***
	(0.04)	(0.04)	(0.05)	(0.04)	(0.90)
2017/07 to 2018/06	-0.06	-0.003	-0.02	-0.25***	4.72***
	(0.08)	(0.08)	(0.06)	(0.05)	(1.05)
2018/07 to 2019/02	-0.16***	-0.08**	-0.03	-0.34***	6.63***
	(0.03)	(0.03)	(0.03)	(0.04)	(0.97)
Sample Mean	2.19	1.72	0.36	0.20	-4.18
Observations	44	44	44	348	348
Cohort FE				X	X
Cohort x CPR Diff Interaction				X	X
Controls				X	X

Note: Aggregate time series regressions of the Fannie Mae-Freddie Mac difference in Log(Volume), Log(Volume/Outstanding), and Log(Issuance), as well as panel regressions of Price and OAS gaps, controlling for differences in MBS characteristics by cohort. Unreported controls for the Price and OAS regressions include Fannie Mae projected 3-month CPR, Baa-Aaa spread, and Fannie Mae agency debt spread (on-the-run 5yr yield minus 5yr swap rate). We restrict the sample to CC-2 to CC+6 for the panel regressions to ensure that cohorts are reasonably liquid; we do not impose this restriction on the aggregate time series regressions. Sample period: July 2015 to February 2019. Data are for front-month settling MBS. Libor OAS is winsorized at the 1% level. Source: Volume data are from FINRA TRACE. Balance outstanding and issuance data are from eMBS. Price and OAS data are from J.P. Morgan DataQuery. HAC robust standard errors in parentheses. Errors are clustered by month. Significant at *p<0.10, **p<0.05, ***p<0.01.

forward contracts are consolidated in June 2019, MBS forward prices have already nearly fully converged by the time UMBS trading begins.

6.2 Comparison to Ginnie Mae

As a way to assess overall changes in Fannie Mae and Freddie Mac TBA liquidity during the transition to UMBS, we use Ginnie Mae as a comparison group, given that Ginnie Maes also trade in the TBA forward market but were not part of the Single Security Initiative. The mortgages underlying Ginnie MBS (backed by government agencies, primarily the FHA and VA) have different prepayment characteristics to the conventional loans in Fannie Mae and Freddie Mac pools; however we can at least partially control for these prepayment risk differences using the CPR difference $\times$ moneyness dummies or by examining trends in OAS which should in principle account for prepayment risk.

We obtain data on monthly new issuance, outstanding balance, price, OAS, and characteristics of Ginnie MBS from eMBS and J.P. Morgan Markets. We then estimate panel regressions similar to the prior table but including data for all three agencies, again including indicator variables for each year after June 2016. Results are presented in Table 7.

From Panel A, we observe that trading volume and issuance of Freddie MBS increased significantly in the period leading up to UMBS compared to Ginnie Mae. Furthermore, in panel B, there is a relative increase in TBA prices and a corresponding decline in OAS for Freddie Mac relative to Ginnie Mae.[31]

Notably, there is no evidence in Table 7 that prices or trading volume for Fannie Mae deteriorated relative to Ginnie Mae as UMBS implementation approaches.[32] This is significant because as we have discussed, critics of the Single Security Initiative expressed concerns that UMBS may *reduce* liquidity for Fannie Mae, the previously liquid segment. We return to this point below.

[31] An additional consideration is that this sample period coincides with the implementation of the bank liquidity coverage ratio (LCR) rule under Basel III. The LCR began to phase in at the start of 2014, and favors Ginnie Mae MBS relative to Fannie and Freddie MBS. He and Song (2020) find evidence that the liquidity premium on Ginnie Mae securities increases around 2014 when the LCR rule started to phase in. To the extent that prices and trading volume had not already fully adjusted to the new rule, LCR implementation would lead to an increase in Ginnie Mae prices and volume leading up to UMBS, biasing us against finding coefficients of the opposite sign in Table 7.

[32] There is a temporary increase in OAS and decline in prices during the 2016-17 period, but it is not persistent. In contrast, we would expect these effects to become larger as UMBS implementation approaches under the hypothesis that the market expected worse liquidity for Fannie Mae post-UMBS.

Table 7: **Fannie & Freddie vs Ginnie: Volume, Issuance, and Price**

	Fannie-Ginnie	Freddie-Ginnie	Fannie-Ginnie	Freddie-Ginnie	Fannie-Ginnie	Freddie-Ginnie
	A: Trading Volume and Issuance					
	Log(Volume)		Log(Volume/Balance)		Log(Issuance)	
Time dummies:						
2016/07 to 2017/06	0.01	0.24***	0.05	0.24***	0.06**	0.10**
	(0.04)	(0.06)	(0.05)	(0.06)	(0.03)	(0.04)
2017/07 to 2018/06	0.10	0.16**	0.15**	0.15**	0.20***	0.22***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.04)	(0.05)
2018/07 to 2019/02	0.26***	0.41***	0.29***	0.37***	0.33***	0.36***
	(0.05)	(0.05)	(0.06)	(0.05)	(0.03)	(0.03)
Sample Mean	1.53	-0.66	1.26	-0.46	0.04	-0.32
Observations	44	44	44	44	44	44
	B: Price Gap and OAS					
	Price Gap (% of par)		Libor OAS (bp)			
Time dummies:						
2016/07 to 2017/06	-0.30**	-0.09	6.61**	2.25		
	(0.15)	(0.14)	(2.99)	(2.76)		
2017/07 to 2018/06	0.15	0.39**	-1.20	-5.87*		
	(0.19)	(0.19)	(3.37)	(3.32)		
2018/07 to 2019/02	0.04	0.38***	-1.45	-8.11***		
	(0.15)	(0.12)	(2.44)	(1.87)		
Sample Mean	0.02	-0.12	-2.56	1.77		
Observations	348	348	348	348		
Cohort FE	X	X	X	X		
Cohort x CPR Diff Interaction	X	X	X	X		
Controls	X	X	X	X		

Note: Aggregate time series regressions of differences in Log(Volume), Log(Volume/Balance), Log(Issuance), as well as panel regressions of differences in Price and Libor OAS, on indicators for after the June 2016 UMBS announcement and each year after August 2016. Unreported coefficients for the Price and OAS regressions include Fannie Mae projected 3-month CPR, Baa-Aaa spread, and Fannie Mae agency debt spread (on-the-run 5yr yield minus 5yr swap rate). Sample period: July 2015 to February 2019. We restrict the Price & OAS sample to CC-2 to CC+6 to ensure that cohorts are reasonably liquid; we do not impose this restriction on the aggregate time series regressions. Data are for front-month settling MBS. Libor OAS is winsorized at the 1% level. Source: Volume data are from FINRA TRACE. Balance/issuance data are from eMBS. Price/OAS data are from J.P. Morgan DataQuery. HAC robust standard errors in parentheses. Errors are clustered by month. Significant at *p<0.10, **p<0.05, ***p<0.01.

To sum up, results in Table 7 show that the convergence between Fannie Mae and Freddie Mac in price and OAS (and to a lesser extent trading volume) prior to UMBS implementation arises indeed from an improvement in the Freddie Mae TBA segment, as opposed to a deterioration for Fannie Mae.

6.3 Prepayment Speeds

As discussed in Section 3 and highlighted in Hypothesis 5, TBA liquidity relies on maintaining a high degree of homogeneity within each TBA cohort, in order to minimize ad-

verse selection. Critics expressed concerns that UMBS might have perverse negative effects on market liquidity for Fannie Mae, the previously liquid TBA segment, by increasing the degree of asset heterogeneity within each cohort. It was feared this would in turn lead to greater basis risk between TBA prices and the value of a typical pool, and possibly lead to "unravelling" in which adverse selection leads higher-value pools to migrate to trading in the fragmented specified pool market rather than the TBA market.

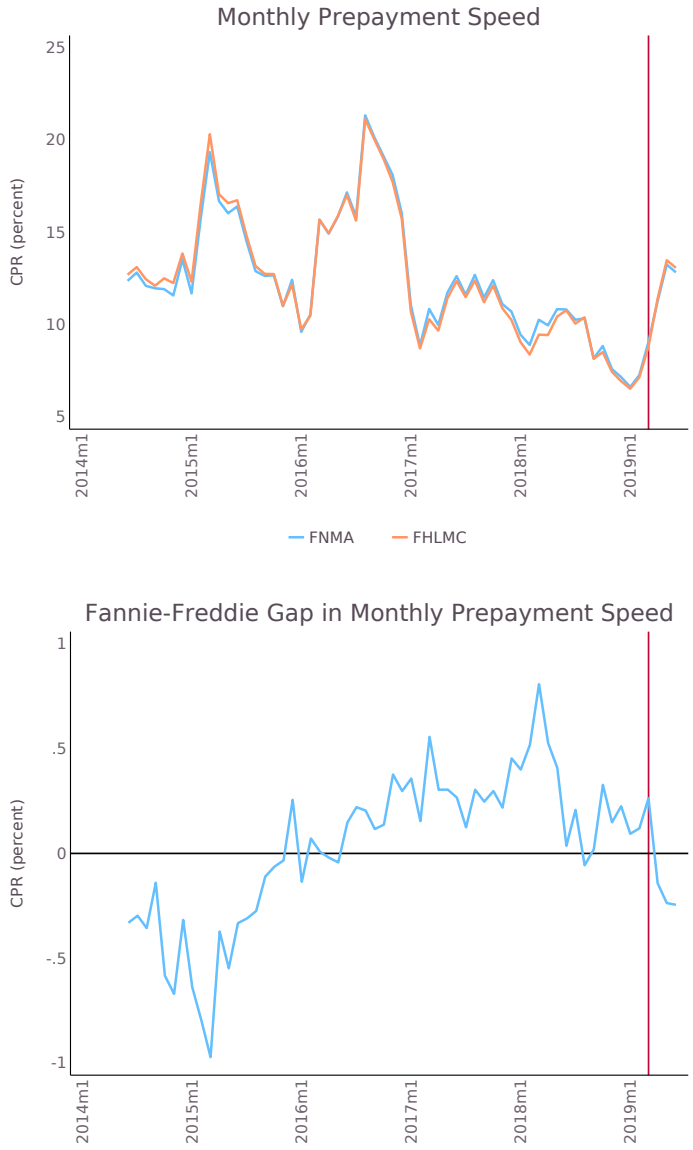
To address these concerns, the FHFA and GSEs undertook several steps during the UMBS transition period to align the characteristics of Fannie Mae and Freddie Mac pools. Policies and practices that could materially affect prepayments were harmonized between the two agencies, including the design of representations and warranties, documentation requirements for borrowers, and policies about when loans can be removed from MBS pools by the GSE (FHFA, 2016, 2019a).[33] The final UMBS rule also included other steps to preserve homogeneity, including an upper bound on the interest rate premium on individual mortgages relative the coupon of the pool into which they are securitized, a cap on servicing fees, and thresholds under which material differences in cohort prepayment speeds between the two GSEs will be flagged and investigated, measured based on either the prepayment speed of the overall cohort or the fastest-paying quartile of the cohort (FHFA (2019b)). These prepayment metrics are tracked through a new FHFA quarterly prepayment monitoring report.

Were these steps successful in maintaining the level of cohort-level homogeneity in pool characteristics (Hypothesis 5)? To investigate this question Figure 5 plots series of annualized monthly realized prepayment rates averaged (weighted by outstanding balance) across all outstanding Fannie and Freddie 30-year fixed-rate MBS, respectively, and their difference. These series are provided by eMBS. The sample period is from June 2014 to June 2019.

The figure shows that the difference in prepayment rates between Fannie Mae and Freddie Mac pools is relatively low, less than 1 percentage point throughout the period. The difference in speeds also diminishes from 2016 onwards, during the UMBS implementation period. Furthermore, during this transition period Freddie Mac prepayment

[33] The GSEs also monitor the prepayment behavior of individual loan sellers and can request the seller to investigate outliers driven e.g., by the practices of particular loan officers. They also at times ask sellers to refrain from refinance solicitations early in the life of the loan, require refunds for loans prepaid early in the loan's life, and cap the amount of origination costs that are rolled into a higher-interest rate loan. In some cases the GSEs may induce fast-prepaying sellers to securitize their loans through single-seller pools which are designated as non-TBA eligible. See FHFA (2019a)) for more details.

Figure 5: **Fannie–Freddie Gap in Prepayment Speed**



Note: The top panel plots monthly series of annualized monthly realized prepayment rates averaged (weighted by outstanding balance) across all outstanding Fannie and Freddie 30-year fixed-rate MBS in percent, respectively. The bottom panel plots monthly series of the difference in Fannie and Freddie MBS prepayment rates (i.e. the difference of the two series in the top panel). The red vertical line indicates the final implementation of UMBS in March 2019. Sample Period: June 2014 to June 2019. Source: eMBS.

speeds are almost uniformly *slower* than Fannie Mae. This is significant because concerns about "unravelling" were driven by the fact that Freddie Mac pools historically prepaid more quickly, and therefore were less valuable, at least for a typical cohort trading at a premium to par. In short, this evidence suggests that aligning practices helped mitigate the risk of unravelling due to an increase in within-cohort heterogeneity.

6.4 Post-Implementation

We now study market liquidity after UMBS forward trading begins in March 2019 and issuance begins in June of the same year. By construction, UMBS eliminates the price and trading cost differential that previously existed between Fannie Mae and Freddie Mac. However we can examine whether trading volume, issuance and pricing changes post-UMBS either in absolute terms or relative to Ginnie Mae.

Panel A of Table 8 reports estimates from difference-in-differences regressions of the trading volume and issuance of the two GSEs (the sum across Fannie and Freddie MBS before June 2019, and UMBS afterwards), with Ginnie Mae MBS as a comparison group. The estimate of interest is the coefficient on the interaction term GSE $\times$ post-March-2019. Notably, this coefficient is not statistically significant in any of the four columns, indicating that the model is unable to detect evidence that consolidation impaired overall TBA market quality in the GSE segment (consistent with our previous results).

Panel B uses similar specifications to study price and OAS. Given that Fannie Mae is the liquid segment prior to UMBS, we compare Ginnie Mae to Fannie Mae pre-UMBS and to UMBS TBAs after the UMBS implementation date. Looking at columns 1 and 2, the coefficient on the interaction term is negative for price and positive for OAS, both highly significant, indicating an adverse effect of UMBS implementation on security prices. However, the following two specifications show these results are no longer statistically significant when time trends are included in the specification.

This final set of tests is relatively low-powered given the short time period available around UMBS implementation. However we are at least able to rule out the hypothesis that implementation had large negative effects on market quality for Fannie Mae.

Table 8: **Liquidity Changes after UMBS Implementation**

A: Trading Volume and Issuance				
			Log(issuance)	
	Log(Volume)	Log(Volume/Balance)	FNMA vs GNMA	FHLMC vs GNMA
	(1)	(2)	(3)	(4)
Post 2019/03	0.20***	0.16***	0.32***	0.32***
	(0.05)	(0.06)	(0.12)	(0.12)
GSE	1.78***	1.03***	0.20***	-0.18***
	(0.03)	(0.03)	(0.03)	(0.05)
GSE × (Post 2019/03)	-0.04	-0.06	-0.04	0.02
	(0.07)	(0.07)	(0.05)	(0.10)
Sample Mean	26.82	-1.63	24.15	23.98
Observations	46	46	46	46
B: Price and OAS [Fannie Mae - Ginnie Mae]				
	Price	Libor OAS	Price	Libor OAS
	(1)	(2)	(3)	(4)
Post 2019/03	0.52	-0.78	1.50*	-15.98*
	(0.65)	(4.98)	(0.89)	(9.39)
GSE	0.31***	-6.27***	0.15***	-3.53**
	(0.08)	(1.24)	(0.03)	(1.40)
GSE × (Post 2019/03)	-0.37***	12.11***	0.03	5.11
	(0.12)	(2.81)	(0.13)	(4.14)
Sample Mean	103.39	47.18	103.39	47.18
Cohort FEs	X	X	X	X
Time Trend			X	X
GSE × Time Trend			X	X
Observations	368	368	368	368

Note: Estimates from difference-in-differences regressions studying the effect of UMBS implementation on the GSEs' and Ginnie Mae's trading volumes, volumes/balances, issuance, prices, and OAS. Volume, volume/balance, and issuance regressions are for an aggregate time series across cohorts; price and OAS regressions are for a panel of coupon cohorts. Sample Period: January 2018 to Nov 2019. We restrict the Price and OAS sample to CC-2 to CC+6 to ensure that cohorts are reasonably liquid. Data are for front-month settling MBS. Libor OAS is winsorized at the 1% level. Source: Volume data are from FINRA TRACE. Balance outstanding and issuance data are from eMBS. Price and OAS data are from J.P. Morgan DataQuery. HAC robust standard errors in parentheses. Errors are clustered by month. Significant at *p<0.10, **p<0.05, ***p<0.01.

6.5 Guarantee Fees

Now we examine the effects of UMBS implementation on guarantee fees. As we have discussed, a key goal of the Single Security Initiative was to place Freddie Mac on an equal footing with Fannie Mae in terms of its rate of return to funding mortgages through securitization (Hypothesis 6). We test this hypothesis by examining the difference in guarantee fees between the two agencies before, during and after the implementation of UMBS.

Results are presented in Figure 6. The difference in guarantee fees between Fannie Mae and Freddie Mac on new mortgage purchases averaged around 5 basis points prior to UMBS. But this fee gap dropped sharply in Q2:2019, when UMBS issuance began, and then declined further to a small *negative* value in 2019:Q3, the first full quarter after UMBS implementation. The gap in relative guarantee fees remains near zero until 2020:Q4, the end of the sample period. In a formal statistical test, this change in relative guarantee fees post-UMBS is statistically significant at the 1% level.[34]

To sum up, the evidence in this section suggests that UMBS implementation improved the liquidity of Freddie Mac MBS without measurably affecting liquidity for Fannie Mae, the previously liquid segment. As a result, Freddie Mac was able to remove discounts provided to primary market sellers to compensate for the illiquidity of its securities, leading to a convergence in guarantee fee income for the two agencies.

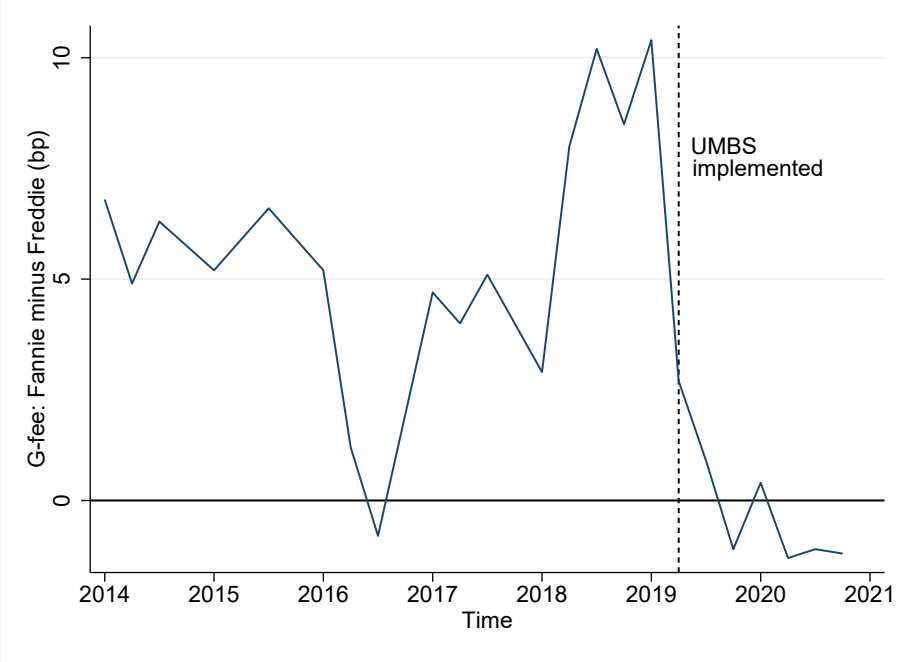
7 Conclusion

We find that the fragmentation of agency MBS forward trading resulted in a concentration of market liquidity in the Fannie Mae segment, leading to higher issuance and trading volume, lower transaction costs, higher security prices and ultimately a higher rate of return to mortgage securitization for Fannie Mae. Furthermore we find that the change in market structure engineered by the Single Security Initiative has eliminated the liquidity disadvantage of Freddie Mac without resulting in a noticeable deterioration in liquidity for Fannie Mae, the previously liquid segment.

The evidence in this paper provides a case study from a large, complex financial mar-

[34] This test is implemented by regressing $\text{gfee}_{fan} - \text{gfee}_{fred}$ on a post-UMBS dummy equal to 1 from 2019:Q2 onwards, using Newey-West standard errors (with three lags) to account for serial correlation. The sample period is 2014 to 2020. The point estimate on the post-UMBS variable is -5.2bp with a t-statistic of 5.5.

Figure 6: **Difference in Guarantee Fees between Fannie Mae & Freddie Mac**



Note: Difference between Fannie Mae and Freddie Mac average guarantee fees (in basis points) on newly securitized mortgages, reported in annual basis points. Note that historical reported g-fees are sometimes revised due to changes in methodology regarding how up-front fees, buy-ups and buy-downs are amortized over time. In cases where figures are revised, we use the most recently reported number. Source: Fannie Mae and Freddie Mac 10-Q and 10-K filings.

ket that market interventions can improve overall liquidity, consistent with a number of theoretical models that suggest the decentralized equilibrium trading structure is not necessarily optimal. The completion of the Single Security Initiative also has significant broader policy implications; in particular it expands the range of options for future reform of the U.S. housing finance system.

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Internet Appendix for "Defragmenting Markets: Evidence from Agency MBS"

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A Historical Development of Agency MBS & TBA Trading

The first U.S. mortgage-backed securities were issued in 1970 by Ginnie Mae. Freddie Mac followed shortly thereafter, issuing its first mortgage pass-through security in 1971, while Fannie Mae began issuing MBS in 1981.

As this chronology suggests, Freddie Mac was an early adopter of MBS financing relative to Fannie Mae, which instead tended to retain and finance mortgages on-balance-sheet. Even so, Fannie Mae was the older and more established of the two GSEs[1], and always bore the credit risk of a larger total volume of mortgages than its competitor. Over time, Fannie Mae overtook Freddie Mac in terms of the volume of MBS issued and outstanding, and as a result of this larger flow and stock, became the benchmark for trading agency MBS in the TBA market.

Table A1: **Historical Growth in Agency Mortgage Securitization**

Fannie Mae and Freddie Mac Assets and Mortgage-Backed Securities and the Mortgage Market

(in billions of dollars, includes single- and multi-family mortgages)

	Fannie Mae			*Freddie Mac*			
Year	*Total assets*	*Retained mortgage portfolio*[a]	*Mortgage-backed securities outstanding*[b]	*Total assets*	*Retained mortgage portfolio*[a]	*Mortgage-backed securities outstanding*[b]	*Total nonfarm, residential mortgages*
1980	$ 57.9	$ 55.6	$ 0.0	$ 5.5	$ 5.0	$ 17.0	$1,105
1985	99.1	94.1	54.6	16.6	13.5	99.9	1,730
1990	133.1	114.1	288.1	40.6	21.5	316.4	2,907
1995	316.6	252.9	513.2	137.2	107.7	459.0	3,745
2000	675.2	607.7	706.7	459.3	385.5	576.1	5,543
2001	799.9	706.8	859.0	641.1	503.8	653.1	6,110
2002	887.5	801.1	1,029.5	752.2	589.9	749.3	6,842
2003	1,009.6	901.9	1,300.2	803.4	660.4	768.9	7,715

[a] Includes repurchased mortgage-backed securities.
[b] Excludes mortgage-backed securities that are held in portfolio.
Sources: OFHEO, Federal Reserve, Freddie Mac.

Note: Reproduced from Frame and White (2005).

These trends can be seen in the above table, which is reproduced from Frame and White (2005). In 1980, Fannie Mae had exposure to $55.6bn in mortgage assets, all of which was held on balance sheet. Freddie Mac had a smaller overall footprint of only

[1] Fannie Mae was founded in 1938, during the Great Depression. Freddie Mac was established in 1970 to provide competition to Fannie Mae after the latter was privatized in 1968. Freddie Mac focused on providing a source of mortgage financing for savings and loans. See Frame and White (2005), Frame, Fuster, Tracy, and Vickery (2015) and Acharya, Richardson, Nieuwerburgh, and Wright (2011) for more historical details about the two GSEs.

$22bn, although the bulk of this, $17bn, was in the form of agency MBS. Over time, however, Fannie Mae relied increasingly on securitization for funding its mortgage portfolio. Fannie Mae passed Freddie Mac in terms of the total stock of MBS outstanding between 1990 and 1995, and the gap widened significantly thereafter. Furthermore, a larger percentage of Freddie Mac pass-through pools are resecuritized into collateralized mortgage obligations (CMOs)[2], further widening the gap in the float of pass-through pools available for TBA trading between the two GSEs.

Over the period from 1980 until the financial crisis, both Fannie Mae and Freddie Mac also grew faster than Ginnie Mae, particularly as the private-label MBS market became an alternative funding source for financing loans to high-credit-risk borrowers.

The TBA market had its origins in the 1970s, before Fannie Mae became an active issuer of agency MBS. However, by the 2000s the much larger float of Fannie Mae pools outstanding meant that the Fannie Mae TBA market was significantly larger and thicker than for either Freddie Mac or Ginnie Mae, and had become the preferred market for hedging or expressing price views on agency MBS. As discussed in the main text, this created a virtuous cycle, further reinforcing the liquidity of the Fannie Mae TBA market, and helping Fannie Mae to reinforce its dominant position in the agency MBS market.

[2]Freddie Mac was a pioneer in the CMO market, issuing the first CMOs in 1983. For a colorful account of the development of the CMO market during this period, see the finance classic *Liar's Poker* by Michael Lewis (Lewis, 2010).

B Measures of Transaction Costs

The round-trip transaction cost measure is computed as the difference between the volume-weighted average price of dealers' selling to customers and volume-weighted average price of dealers' buying from customers, for each TBA contract on each day. We require that at least two transactions – one sale of dealers to customers and one purchase of dealers from customers – be available to compute a round-trip transaction cost measure on a day. We also discard the round-trip transaction cost estimates that are available for either Fannie Mae or Freddie Mac MBS but not both.

The Roll (1984) measure, under certain assumptions, is equal to the percentage bid–ask spread. It is computed as two times the square root of minus the covariance between consecutive returns. In particular, for each TBA contract on each day t, we take the sequence of all trades (N_t), and compute a return $R_{t,j}$ using the $j-1$-th and j-th trades, for all $j = 2, 3, \cdot, N_t$. These returns are then used to compute the Roll measure on day t as

$$\text{Roll}_t = 2\sqrt{-cov(R_{t,j}, R_{t,j-1})}.$$

We discard observations with a negative covariance.

The Amihud (2002) measure captures the price impact of a trade per unit traded. For each TBA, we calculate the Amihud measure as the daily average of absolute returns divided by the trade size (in million) of consecutive transactions:

$$\text{Amihud}_t = \frac{1}{N_t}\sum_{j=1}^{N_t}\frac{|R_j|}{Q_j}$$

where N_t is the number of returns on day t and Q_j is the size of the j-th trade. At least two transactions are required on a given day to calculate the measure,

C Additional Results and Robustness Checks

Table C1: **Trading Volume, Price, & OAS of Back-Month TBA Contracts**

	Back Month	Back2 Month
A: Log(Volume)		
Constant	2.36***	2.47***
	(0.05)	(0.06)
Observations	62	62
B: Log(Volume/Outstanding Balance)		
Constant	1.85***	1.96***
	(0.05)	(0.07)
Observations	62	62
C: Adjusted Price Gap (% of par)		
Constant	0.16***	0.25***
	(0.03)	(0.04)
Cohort FE	X	X
Cohort x CPR Diff Interaction	X	X
Sample Mean	0.20	0.25
Observations	1232	906
D: Libor OAS (bp)		
Constant	-3.98***	-4.97***
	(0.378)	(0.50)
Cohort FE	X	X
Cohort x CPR Diff Interaction	X	X
Sample Mean	-4.97	-5.94
Observations	1232	906

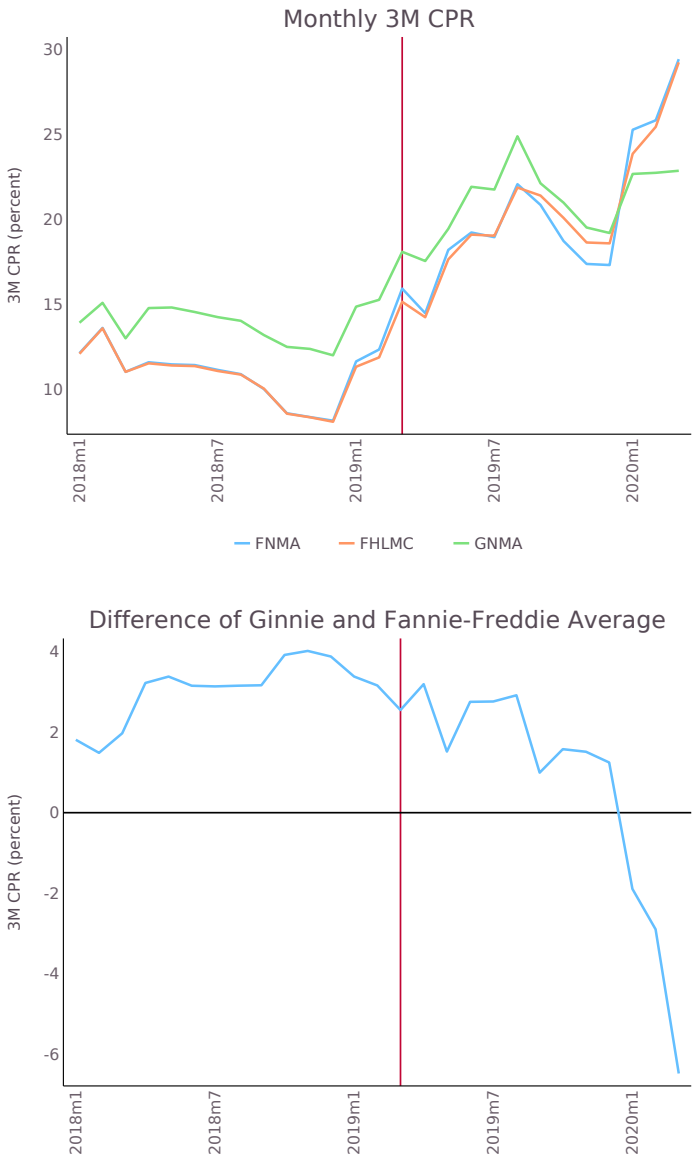
Note: Aggregate time series regressions of the Fannie Mae-Freddie Mac difference in Log(Volume) and Log(Volume/Balance), as well as panel regressions of Log(Price) and Log(Libor OAS), for back- and back2-settling MBS contracts on a constant term. Sample Period: May 2011 to June 2016 for volume data and January 1998 to June 2016 for price/OAS data. We restrict the sample to CC-2 to CC+6 for the Price/OAS regressions to ensure that cohorts are reasonably liquid. Libor OAS is winsorized at the 1% level. Source: Volume data are from FINRA TRACE, balance data are from eMBS, and price/OAS data are from J.P. Morgan DataQuery. HAC robust standard errors in parentheses. Errors are clustered by month. Significant at *p<0.10, **p<0.05, ***p<0.01.

Table C2: **Time Series Variation of Fannie–Freddie Gap in Price & OAS (Weighted)**

A: Adjusted Price Gap (% of par)				
	(1)	(2)	(3)	(4)
Fannie 3M CPR	-0.098***			-0.086***
	(0.017)			(0.014)
Baa-Aaa Spread		0.009		-0.019**
		(0.012)		(0.009)
Agency Debt Spread			0.061***	0.058***
			(0.011)	(0.012)
Mean of dep. var.	0.199	0.199	0.209	0.209
Cohort Fixed Effects	X	X	X	X
Cohort x CPR Diff Interaction	X	X	X	X
Observations	1232	1232	1176	1176
Joint Spread P-Value				.04282
B: Libor OAS (bp)				
	(1)	(2)	(3)	(4)
Fannie 3M CPR	1.515***			1.410***
	(0.443)			(0.459)
Baa-Aaa Spread		-0.511*		-0.314
		(0.268)		(0.223)
Agency Debt Spread			-0.659*	-0.328
			(0.343)	(0.320)
Mean of dep. var.	-5.129	-5.129	-5.301	-5.301
Cohort Fixed Effects	X	X	X	X
Cohort x CPR Diff Interaction	X	X	X	X
Observations	1232	1232	1176	1176
Joint Spread P-Value				.4638

Note: Panel regressions of Fannie Mae-Freddie Mac differences in price and OAS gaps on Fannie Mae projected 3-month CPR, Baa-Aaa spread, and Fannie Mae agency debt spread (on-the-run 5yr yield minus 5yr swap rate). We restrict the sample to CC-2 to CC+6 to ensure that cohorts are reasonably liquid. Sample period: January 1998 to June 2016. Data are for front-month settling MBS. Libor OAS is winsorized at the 1% level. Source: J.P. Morgan DataQuery. HAC robust standard errors in parentheses. Errors are clustered by month. Significant at *p<0.10, **p<0.05, ***p<0.01.

Figure C1: **Prepayment speeds by agency around UMBS implementation**



Note: CPR by agency around UMBS implementation. Source: eMBS.