Estimated Impact of the Federal Reserve's Mortgage-Backed Securities Purchase Program*

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The largest credit or liquidity program created by the Federal Reserve during the financial crisis was the mortgage-backed securities (MBS) purchase program. In this paper, we examine the quantitative impact of this program on mortgage interest rate spreads. This is more difficult than frequently perceived because of simultaneous changes in prepayment risk and default risk. Our empirical results attribute a sizable portion of the decline in mortgage rates to such risks and a relatively small and uncertain portion to the program. For specifications where the existence or announcement of the program appears to have lowered spreads, we find no separate effect of the stock of MBS purchased by the Federal Reserve.

JEL Codes: E52, E58, G01.

1. Introduction

As part of its response to the financial crisis, the Federal Reserve introduced a host of new credit and liquidity programs in 2008 and 2009. The largest of the new programs was the mortgage-backed securities (MBS) purchase program. This program was part of a quantitative easing or credit easing policy which replaced the usual tool of monetary policy—the federal funds rate—when it hit the lower bound of zero. The mortgage-backed securities that the Federal Reserve purchased were guaranteed by Fannie Mae and Freddie

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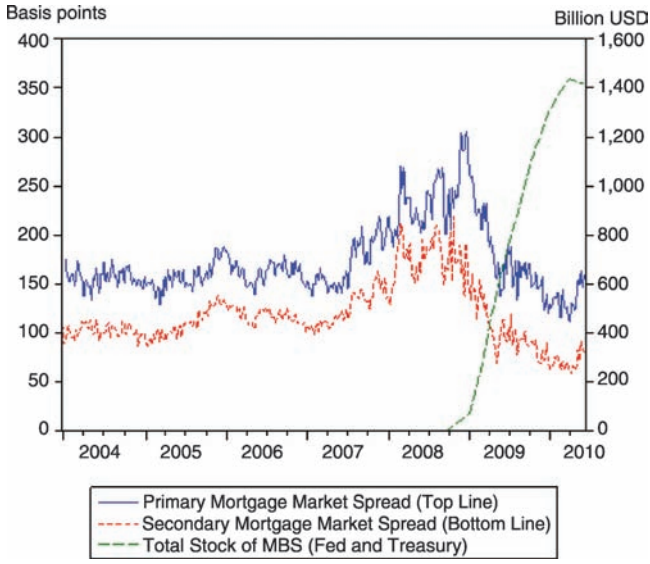
Mac, the two government-sponsored enterprises (GSEs) with this role, as well as by Ginnie Mae, the U.S. government-owned corporation within the Department of Housing and Urban Development. The program was set up with an initial limit of $500 billion but was later expanded to $1.25 trillion. It expired on March 31, 2010. The Federal Reserve also created a program to buy GSE debt—initially up to $100 billion and later expanded to $200 billion—and a program to purchase $300 billion of medium-term Treasury securities. The Federal Reserve's MBS purchases came on top of an earlier-announced MBS purchase program by the Treasury.

These programs were introduced with the explicit aim of reducing mortgage interest rates.[1] Figure 1 shows both primary and secondary mortgage interest rate spreads over Treasury yields during the financial crisis. Primary mortgage rates are the rates that are paid by the individual borrower. They are based on the secondary market rate but also include a fee for the GSE insurance, a servicing spread to cover the cost of the mortgage servicer, and an originator spread. Observe that mortgage spreads over U.S. Treasuries started rising in 2007 and continued rising until late 2008, when they reached a peak and started to decline. By July 2009 they had returned to their long-run average, or to slightly below that average.

In this paper we consider to what degree the decline in spreads in 2009 can be attributed to the purchases of mortgage-backed securities by the Federal Reserve and the Treasury. This question is very important for deciding whether or not to use such programs in the future as a tool of monetary policy. Determining whether central banks have the ability to affect the pricing of mortgage securities for extended periods is also an important input into the debate about the role, responsibilities, and powers of central banks (see, for example, the collection of essays on this subject in Ciorciari and Taylor 2009), and we see this paper as part of a larger empirical analysis of quantitative easing, or credit easing, at central banks during the crisis.

[1]The press release on November 25, 2008 announcing the MBS purchase program stated that "this action is being taken to reduce the cost and increase the availability of credit for the purchase of houses, which in turn should support housing markets and foster improved conditions in financial markets more generally."

Figure 1. Mortgage Spreads and Stock of MBS Purchases



Notes: This figure shows the primary market mortgage spread, the secondary market mortgage spread, and the total stock of MBS purchases by the Federal Reserve and Treasury. The primary market mortgage rate series comes from Freddie Mac's Primary Mortgage Market Survey, which surveys lenders each week on the rates and points for their most popular thirty-year fixed-rate, fifteen-year fixed-rate, 5/1 hybrid amortizing adjustable-rate, and one-year amortizing adjustable-rate mortgage products. The secondary market mortgage series is the Fannie Mae thirty-year current-coupon MBS (Bloomberg ticker: MTGEFNCL.IND). The spreads are created by subtracting the yield on ten-year U.S. Treasuries from both series. The maturity difference between these series captures the fact that most thirty-year mortgages are paid off or refinanced before their maturity. We add MBS to the total stock when they are contracted and reported by the Federal Reserve Bank of New York, not when they appear on the Federal Reserve's balance sheet.

A common perception is that the MBS purchase program led to a significant reduction in mortgage rates. For example, early in the program, in January 2009, Ben Bernanke (2009) noted that "mortgage rates dropped significantly on the announcement of this program and have fallen further since it went into operation." Later, in December 2009, Brian Sack (2009) of the Federal Reserve Bank of New York reiterated that view. Figure 1 shows that the decline in the

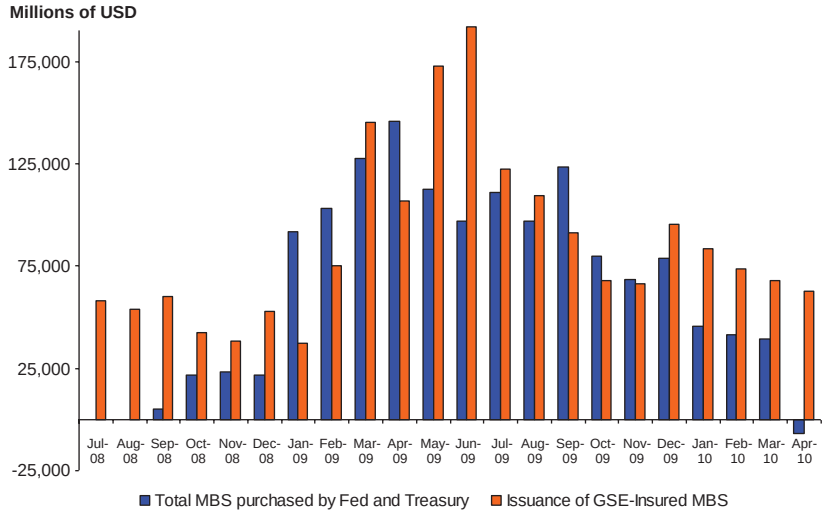
mortgage interest rate spread was contemporaneous to the expansion of the MBS purchase program.[2] Some also cite the large fraction of new agency-insured MBS issuance that the Federal Reserve has purchased each month since the start of the purchase program.[3] Figure 2 shows that MBS purchases in 2009 were up to 200 percent of new issuance of GSE-insured debt, and a significantly larger fraction of net issuance.

In our view, however, an evaluation of the program's impact requires an econometric analysis that controls for influences other than the MBS purchase program on mortgage spreads. In particular, any coherent story that links the decline in mortgage interest rates to the purchases of MBS by the Federal Reserve also needs to explain why mortgage spreads increased so dramatically between 2007 and late 2008, and consider whether those same factors may be responsible for at least part of the subsequent decline in 2009. It is conceivable that precisely those indicators of risk in mortgage lending that drove up mortgage spreads through 2007 and 2008 relaxed

[2]MBS purchases are primarily made in the "to be announced" (TBA) market in which the pool identity is unknown at the time of the purchase. The TBA contract defines the MBS that will be delivered only by the average maturity and coupon of the underlying mortgage pool, and by the GSE backing the MBS. For example, an investor might purchase $1 million worth of 8 percent, thirty-year Fannie Maes for delivery next month. Precise pool information is then "to be announced" forty-eight hours prior to the established trade settlement. This allows a lender to lock in the rate they can offer the mortgage borrowers by preselling their loans to investors, and thus to fund their origination pipeline. For more details on this market, see Boudoukh et al. (1999). The Federal Reserve Bank of New York announced MBS purchases when they contracted to buy; the Federal Reserve placed the MBS on its balance sheet (reported in the H.41 release) when the contract settled. This explains why at the end of the MBS purchase program, on March 31, 2010, the Federal Reserve had just over $1 trillion of MBS on its balance sheet, rather than $1.25 trillion, which is the overall size of the program. In this paper we record the volume of purchases when they are contracted and reported by the Federal Reserve Bank of New York, not when they appear on the Federal Reserve's balance sheet. A robustness check has shown that this does not affect our conclusions.

[3]This point was also made by Sack (2009): "How has the Federal Reserve been able to generate these substantial effects on longer-term interest rates? One word: size. The total amount of securities to be purchased under the LSAPs is quite large relative to the size of the relevant markets. That is particularly the case for mortgage-backed securities. Federal Reserve purchases to date have run at more than two times the net issuance of securities in this market."

Figure 2. Monthly Flows of GSE-Insured MBS Issues and Shares Bought by the Federal Reserve and Treasury



Note: This figure shows the monthly purchases of MBS by the Federal Reserve and Treasury, as well as the total monthly issuance of GSE-insured MBS.

throughout the first half of 2009, providing a coherent theory for both the rise and the subsequent fall of mortgage spreads, without a large role for the Federal Reserve's purchases. While identifying the effects of the Federal Reserve's MBS purchases is complicated by the many unusual developments in financial markets between 2007 and 2009, we attempt to address the issue empirically using statistical methods and available data.

A number of other recent papers have considered the effect of large-scale asset purchase (LSAP) programs since the initial publication of our results.[4] Gagnon et al. (2011) examine the cumulative effect of eight different announcements related to long-term asset

[4]Our original estimates of the impact of the MBS purchases on mortgage spreads were performed in "real time" while the Federal Reserve was still making purchases under the MBS program and were presented briefly in preliminary form in the NBER Feldstein lecture in July 2009 and circulated in December 2009 as NBER Working Paper No. 15626.

programs, including the MBS purchases. They find the current-coupon thirty-year agency MBS yield to decline by a total of 113 basis points (recall that we are considering spreads, not yields). This approach assumes that the markets correctly and completely price in the information contained in the announcement within the one-day window of the baseline analysis. We consider our analysis to be complimentary to approaches looking at announcement effects. Hancock and Passmore (2011) examine whether the MBS purchase program lowered mortgage rates, and conclude that the program's announcement reduced mortgage rates by about 85 basis points in the month following the announcement, and that it contributed an additional 50 basis points towards lowering risk premiums once the program had started. Fuster and Willen (2010) consider the movement of prices as well as quantities around the announcement of the MBS purchase program. They argue that the number of mortgage applications for refinancing increased around the announcement of the program. They find no effect of the announcement on the search and application for purchase mortgages. In addition, they use a high-frequency data set of loan offers to show that there was a wide variation in the effect of the announcement on mortgage rates. In particular, they detect a range from a fall of 40 basis points to an increase of 10 basis points. Aït-Sahalia et al. (2010) look at announcement effects of programs at a number of central banks. Duygan-Bump et al. (2010) examine short-term liquidity facilities.

In the next section we discuss the theory of the valuation of MBS, and we explain how the option-adjusted spread (OAS) can be used to control for the prepayment risk inherent in MBS valuation. We also discuss our approach to controlling for the default risk of the underlying mortgages. We then report our empirical results. We show that a sizable portion of the decline in mortgage spreads can be attributed to declines in default risk and prepayment risk, a result which is robust to alternative measures of mortgage spreads, including other OAS series and simple spreads between mortgage rates and Treasuries or interest rate swaps. We then show that the estimated size of the impact of the MBS program on mortgage spreads is sensitive to which interest rate the spread is measured relative to. We explore the reason for this difference and find that it can be

traced to a shift in the spread between Treasuries and swaps which occurred around the time of the panic in October 2008.[5]

2. Valuing Mortgage-Backed Securities

Mortgage-backed securities are structured financial products that are secured by a collection of mortgages, most commonly on residential property. Mortgage loans made by individual lenders are assembled into pools by Fannie Mae, Freddie Mac, Ginnie Mae, or private entities. Mortgage-backed securities then represent a claim on the principal and interest of the mortgage loans in the pool. The Federal Reserve's MBS purchases concentrated on the market for mortgage-backed securities assembled and insured by Fannie Mae, Freddie Mac, and Ginnie Mae. These institutions guarantee the timely payment of principal and interest of those mortgage-backed securities, even if the underlying mortgages default (Passmore 2005).

Basic finance theory suggests that for given intertemporal preferences, there are two key determinants of the spread of mortgage-backed securities over the risk-free rate. These determinants are the prepayment risk and the default risk of the MBS. Most of the mortgages that collateralize a mortgage-backed security entail a prepayment option for the individual borrower, which gives the borrower the right to prepay the mortgage at any time prior to the maturity of the loan, and thereby to refinance at a favorable rate. This prepayment option gives mortgage-backed securities characteristics similar to those of a callable bond in which the issuer has the right to redeem prior to its maturity date (Windas 1996). In the case of MBS, when interest rates decline, mortgage holders might choose to prepay their mortgage and refinance at lower rates. This terminates the investors' source of above-market returns and requires them to reinvest at the lower prevailing rates. To compensate an investor for the presence of this prepayment risk, coupon payments on MBS must be adjusted upwards. To determine how much of the observed

[5]If the MBS program also lowered Treasuries or swaps, then the effects of the purchase program on mortgage rates could be larger than what we detect. Sack (2009) stresses that "a primary channel through which this effect takes place is by narrowing the risk premiums on the assets being purchased." But he also states that the effect "would be expected to spill over into other assets that are similar in nature."

fall in mortgage spreads can possibly be attributed to a decline in prepayment risk, we use several different option-adjusted spreads, which we explain below in section 2.1.

A second key determinant of MBS pricing is the default risk of those securities. Falling house prices, rising foreclosures, and increasing inventory in the housing market all contribute to a higher default probability for the underlying mortgages. As we described above, the Federal Reserve's purchases were limited to the market of mortgage-backed securities guaranteed by Fannie Mae, Freddie Mac, and Ginnie Mae. The default risk of these agency-insured MBS is thus not only affected by the default risk of the underlying mortgages but also by the perceived probability that the insuring entity will not be able to fulfill its insurance pledge. While Ginnie Mae securities are the only MBS that carry the full faith and credit guarantee of the U.S. government, many market participants believed that there was also an "implicit guarantee" for the MBS guaranteed by Fannie Mae and Freddie Mac. In section 2.2 we discuss a number of approaches we take to control for the default risk of agency-insured MBS.

2.1 Controlling for Prepayment Risk

As discussed above, the individual mortgage borrower usually has the option to prepay the mortgage in part or in full at any time prior to its maturity. Provisions allowing for borrower prepayment prior to the maturity of a loan are referred to as embedded options. To compensate the investor for the presence of this prepayment risk, coupon payments on MBS must be adjusted upwards. Pricing of a mortgage-backed security thus proceeds by modeling it as a combination of (i) a long position in a non-callable bond and (ii) a short position in a prepayment option. The combined valuation of those two parts determines the secondary market yield of MBS (for a discussion of the extent to which the option approach can explain default and prepayment behavior, see Deng, Quigley, and Van Order 2000).

The option-adjusted spread (OAS) is a natural way to control for these prepayment risks. It is calculated by considering the average discounted cash flow from the MBS along a number of possible interest rate scenarios (below we discuss how these scenarios are generated). To define the OAS, let r_{it} represent the short-term interest

rate at time t under scenario i and let C_{it} represent the cash flow from the mortgage-backed security at time t under scenario i. (Note that the cash flow path depends on the interest rate path, as discussed below). The present value of the cash flows for each scenario i is given by

$$PV_i = \sum_{k=1}^{K} \frac{C_{ik}}{\prod_{j=1}^{k}(1 + r_{ij})}. \tag{1}$$

Hence, the theoretical value P_E of the MBS is equal to the probability-weighted average of the PVs of each scenario. Let $w(i)$ be the probability of each interest rate and cash flow scenario.[6] Then

$$P_E = \sum_{i=1}^{N} w(i) PV_i \quad \text{s.t.} \sum_{i=1}^{N} w(i) = 1. \tag{2}$$

If we denote the market value of an MBS by P_M, then the OAS is defined as the θ such that

$$P_M = \sum_{i=1}^{N} w(i) \left[\sum_{k=1}^{K} \frac{C_{ik}}{\prod_{j=1}^{k}(1 + r_{ij} + \theta)} \right]. \tag{3}$$

Thus, the OAS is the spread—over a term structure of interest rates—that equates the market price of the MBS to the probability-weighted average discounted present value of expected cash flows along a number of possible simulated future interest rates paths. In other words, the OAS is the number of basis points θ that the discount curve needs to be adjusted upwards until the theoretical price calculated using the "adjusted term structure" matches the market price of the security.

It is common to use an interest rate model based on the LIBOR swap curve[7] for the projection of r_{it}, in which case the OAS is

[6] If these interest rate scenarios are drawn using Monte Carlo methods, then each scenario would have an equal likelihood, and $w(i) = 1/N$ for all i.

[7] By the LIBOR swap curve, we mean the swap rate as a function of the maturity of the interest rate swap. The swap rate is the rate paid by a fixed-rate payer in return for receiving floating-rate three-month LIBOR rolled over during the maturity period of the swap. To emphasize that LIBOR is the floating-rate side of the interest rates swaps in this paper, we sometimes use the term LIBOR swap.

referred to as the *swap-OAS*. LIBOR is the most appropriate discount rate for most financial market participants who balance mortgage investments with other non-government investments. LIBOR thus provides a measure of the opportunity cost of most investors. Fabozzi and Mann (2001) argue that "funded investors use LIBOR as their benchmark interest rate. Most funded investors borrow at a spread over LIBOR. Consequently, if the LIBOR swap curve is used as the benchmark interest rate, the OAS reflects a spread relative to their funding costs."[8]

To make the OAS operational, multiple paths of future interest rates must be generated using a model of interest rates. The cash flows from the underlying mortgages can then be calculated using the generated interest rates. Three swap-OAS series are used in this paper. We first focus on a Bloomberg series which is widely used by market participants. The interest rate path and cash flow path for this series are calculated using the Bloomberg "two-factor interest rate" and "prepayment" models. We show that the results are robust to using two other swap-OAS series which are based on different models (one by Barclays Capital, the other by Deutsche Bank). The results from using these series are very similar to those obtained using the Bloomberg series. The OAS can also be calculated using an interest rate model based on Treasury securities rather than LIBOR, and we also consider this alternative measure, which we call *Treasury-OAS* in our analysis. However, Treasury rates and interest rate swap rates behaved quite differently during the financial crisis, and some of the results are different for this alternative, as we discuss below.

The interest rate model used to compute the Bloomberg OAS series, which is described in Belikoff et al. (2010), is a time-series model which assumes no-arbitrage conditions on the term structure of interest rates. For the swap-OAS, the no-arbitrage conditions are imposed using the LIBOR swap curve, and for the Treasury-OAS, the no-arbitrage conditions are imposed using the constant-maturity

[8]Belikoff et al. (2010) also address this issue. They argue that using the LIBOR swap curve has the additional advantage that "the swap market is quoted more uniformly and more densely [than the Treasury market]," which helps with calibrating the interest rate model used to determine the OAS. Consequently "the mortgage market has evolved to value securities relative to the swap market."

Treasury (CMT) curve. Brigo and Mercurio (2006) discuss the value of using more than one factor in such time-series models for the interest rates as well as the rationale for imposing no-arbitrage conditions. Rudebusch (2010) discusses the benefit of adding macro variables to these interest rate models.

The prepayment model, also described in Belikoff et al. (2010), takes into account refinancing as well as housing turnover, curtailment (when the debtor elects to pay more than the required mortgage payment), and default. Refinancing is the major interest-rate-dependent component. Prepayment increases when interest rates are low relative to the MBS's coupon, but it is also affected by credit quality (borrowers with poor credit are less able to refinance), a "media effect" (prepayment jumps when rates hit historic lows), and a "burnout effect" (pools that have experienced substantial prepayment are less likely to prepay in the future, since those members who are most likely to prepay have been removed). Housing turnover is modeled with a seasonally adjusted turnover rate modified by a lock-in effect in which housing turnover is reduced when it is more expensive to close out an existing mortgage. Further adjustments are made to account for the fact that prepayments first tend to increase and then level off over time.[9]

Figure 3 shows the Bloomberg swap-OAS, the Treasury-OAS, and the primary mortgage spread over Treasuries.[10] The gap between the OAS series and the primary mortgage spread partially captures changes in prepayment risk. The gap between the swap-OAS and the Treasury-OAS is driven by movements of the Treasury term structure relative to the swap-curve term structure, as we discuss further below.

2.2 Controlling for Default Risk

While the prepayment models underlying the OAS endeavor to control for prepayment risk, they do not control for default risk.

[9]More details on the computation of option-adjusted spreads can be found in Kupiec and Kah (1999) and in Windas (1996).

[10]In particular, the swap-OAS is the NOASFNCL.IND series and the Treasury-OAS is the MOASFNCL.IND series in Bloomberg. Both series capture the OAS of Fannie Mae thirty-year current-coupon MBS, and are used widely by market participants. The swap-OAS uses the S23 swap curve and the Treasury-OAS uses the constant-maturity Treasury curve.

Figure 3. Option-Adjusted Spread and Primary Mortgage Market Spread

Notes: This figure shows the primary market mortgage spread over ten-year U.S. Treasuries. The primary market mortgage rate series comes from Freddie Mac's Primary Mortgage Market Survey, which surveys lenders each week on the rates and points for their most popular thirty-year fixed-rate, fifteen-year fixed-rate, 5/1 hybrid amortizing adjustable-rate, and one-year amortizing adjustable-rate mortgage products. The figure also shows the swap-OAS for Fannie Mae securities (Bloomberg ticker: NOASFNCL.IND) and the Treasury-OAS for Fannie Mae securities (Bloomberg ticker: MOASFNCL.IND).

Controlling for the default risk of agency-insured MBS is necessary to ensure that the decline in spreads in the OAS in 2009 was not driven by a decline in the default risk of the underlying securities. Finding a good, uncontaminated measure for default risk, however, is not easy. In the case of agency-insured MBS, the default risk is not only related to the default risk of the underlying mortgages but also to the potential of the insuring agency being unable to meet its guarantee obligations. The ability to fulfill such an insurance pledge is a function of the health of the housing market and of a number of political factors that determine whether the government would

eventually act as a backstop to the guarantees. This uncertainty is more relevant for the GSEs Fannie Mae and Freddie Mac than for Ginnie Mae, which has the full faith and credit backing of the U.S. government.

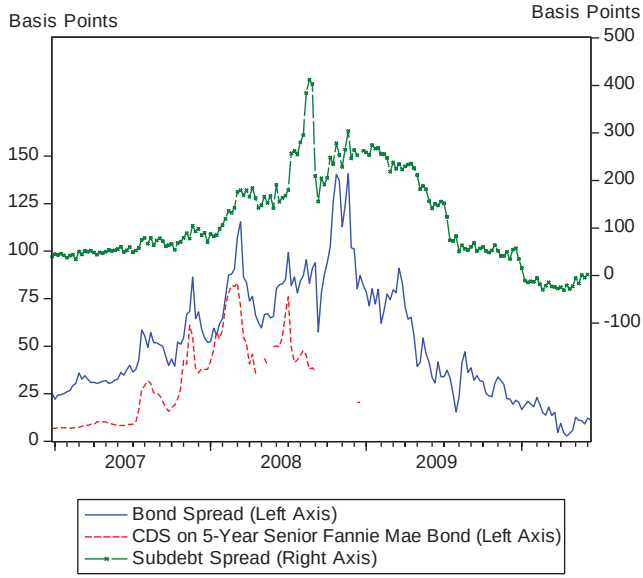
A good measure of the default risk of GSE-insured MBS is the credit default swap (CDS) series on the debt issued by the insuring institutions. When there is an increased risk of default of GSE debt, as measured by higher costs for CDS on that debt, the risk that the GSEs will not be able to fulfill their insurance pledge increases. Consequently, secondary market spreads on agency-insured MBS will increase. Unfortunately, placing Fannie Mae and Freddie Mac into conservatorship on September 7, 2008 was a trigger event for outstanding CDS, so the data series stops at that time. To our knowledge, no new CDS series have emerged since then that would allow us to directly measure GSE default risk.

An alternative proxy for the default risk of Fannie and Freddie is the spread between GSE debt and U.S. Treasury securities. One such series is the spread between five-year Fannie Mae bonds and U.S. Treasury active (on-the-run) securities.[11] There are some concerns that such bond spread series might be picking up liquidity effects as well as changes in default risk (Krishnamurthy 2010). Figure 4 shows this bond spread series together with the associated CDS series prior to its discontinuation. For the time period that the two series coexist, they are highly correlated, which suggests that the bond spread series does pick up changes in the default risk of GSE-insured MBS, and does not just capture liquidity or other effects. Another complicating factor, however, is that in late 2008 the Federal Reserve also embarked on a program to purchase agency debt. While these interventions capture a much smaller fraction of the market than the purchases of agency-insured MBS, they may contaminate the usefulness of bond spreads as a pure measure of agency default risk during this period. To deal with this problem we take two approaches.

First, we instrument for the bond spread series with three instrumental variables: the level of the Case-Shiller house-price index, the

[11] This series is available with the Bloomberg ticker FNMGVN5.IND.

Figure 4. GSE Bond Spreads, Subdebt Spreads, and GSE CDS



Notes: The solid line in this figure shows the spread of five-year Fannie Mae bonds to U.S. Treasury active (on-the-run) securities, given by Bloomberg ticker FNMGVN5.IND. The dashed line shows the CDS series on senior five-year Fannie Mae bonds, given by Bloomberg ticker FNMA 5YR CDS SR Index. The solid line and the dashed line are plotted on the left axis. The solid crossed line shows the development of the spread between a Fannie Mae subordinated debt series (FNMA 4.625 05/01/13) and five-year Treasuries, and is plotted on the right axis.

change in this index, and Moody's AAA bond index.[12] We interpolate the monthly Case-Shiller index data to get weekly observations. A lower level of the house-price index and a large decline in the index should indicate a higher degree of mortgage default risk. Falling house prices will push borrowers into negative home equity,

[12]Moody's Long-Term Corporate Bond Yield Averages are derived from pricing data on a regularly replenished population of corporate bonds in the U.S. market, each with current outstandings over $100 million. The bonds have maturities as close as possible to thirty years; they are dropped from the list if their remaining life falls below twenty years, if they are susceptible to redemption, or if their ratings change.

increasing their incentives for strategic default, and thus increasing the risk of mortgage default. The Moody's AAA bond index captures the general degree of riskiness in the credit markets. Because these instruments are unlikely to be affected by Federal Reserve purchases of GSE debt or MBS and are highly correlated with the bond spread (the first-stage regression has an F-statistic of 99.92), they are good instruments in our view.[13] In addition, beyond its effect through capturing increased risk in the housing credit market, neither of the instruments should have a significant effect on the default probability of GSE debt. Thus the exclusion restrictions are likely to be met. We also ran robustness checks which use the CDS spreads for Bank of America, Wells Fargo, Citigroup, and JP Morgan—four large mortgage lenders in the United States—to instrument for the GSE debt spread, in place of the Moody's AAA index. The results are very similar to those reported with the Moody's AAA index as the instrument.[14]

In a second approach, we use the spreads of Fannie Mae's Subordinated Benchmark Note series to proxy for credit risk. Since the Federal Reserve's GSE debt purchases were focused on the senior debt market, they are less likely to have contaminated this subordinated debt as a proxy of risk. Fannie Mae started issuing subordinated debt in 2001, with the expressed goal of "enhancing market discipline, transparency and capital adequacy." The subordinated debt series is unsecured and ranks junior in priority of payment to all senior creditors, so "the price is sensitive to how the market views our [Fannie's] financial situation" (Fannie Mae 2001). Since MBS guarantees rank pari passu to senior bonds, the subordinated debt will only be repaid if the MBS insurances issued are fulfilled. This means that an increase in the subordinated debt spreads should

[13]One may be concerned that since the Moody's AAA index contains corporate debt, which did not suffer as much during the crisis, it will not pick up the adequate default risk. In addition, there might also be concerns that it could be affected through a portfolio-balance channel. While we do not believe that this is very likely, a robustness check of our results, in which we drop the index from our list of instruments, shows that the inclusion of the index does not affect our conclusions materially.

[14]The results are available on request. The series are CDS series on five-year senior bonds. They have the following Bloomberg tickers: BOFA CDS USD SR 5Y Corp, WELLFARGO CDS USD SR 5Y Corp, CINC CDS USD SR 5Y Corp, and JPMCC CDS USD SR 5Y Corp.

signal an increase in the probability of default for the GSE-insured MBS. The downside of looking at the subordinated debt series is its very small volume, which is usually around $1 billion per issuance and not comparable in liquidity to the senior GSE bonds. Therefore, the pricing of these securities may conflate liquidity elements with credit risk elements. Figure 4 also compares the development of the bond spread series with the subordinated debt spread series[15]—it appears as if the subordinated debt spread series moves more dramatically, especially in the period running up to the conservatorship of Fannie and Freddie, and may thus be more able to pick up changes in default risk.[16]

3. Empirical Analysis

In reporting our results, we first consider the swap-OAS and the simple spread of MBS yields over swap rates. Second, we consider the Treasury-OAS and the simple spread of MBS yields over Treasury yields. Third, we discuss shifts in the swap spread (the spread between swap rates and Treasury rates of the same maturity) that can help to understand the differences in the detected impact of the MBS program on the swap-OAS and Treasury-OAS.

3.1 Spreads over LIBOR Swaps

In the basic model, the option-adjusted spread is a function of the various measures of default risk discussed in section 2.2 (interest rate spreads on Fannie Mae senior debt as well as Fannie Mae subordinated debt, both with and without instruments) and the stock of GSE-insured MBS held by the Federal Reserve and Treasury as a percentage of the total market (about $5 trillion). Both the OAS and the other spreads are measured in basis points (1/100 of a percentage point). The observations are at a weekly frequency. For

[15]Spread of the Fannie Mae Subordinated Benchmark series, Maturity on 5.1.2013, Volume: $1 billion (Bloomberg ticker: FNMA 4.625 05/01/13 Corp) over five-year Treasury.

[16]It is possible that during this time period, and the event surrounding the conservatorship, there were changes in both the probability of default and the expected loss given default, which might affect CDS spreads and bond spreads differentially.

Table 1. Fannie Mae Swap-OAS Regressions with GSE Bond Spreads

	(1) OLS	(2) IV	(3) OLS	(4) IV
Bond Spread	0.87***	0.93***	0.43***	0.39***
	(0.04)	(0.05)	(0.06)	(0.09)
Total MBS Purchases	67.81***	60.15***	34.34***	20.71*
	(11.74)	(12.81)	(10.02)	(12.28)
OAS ($t-1$)			0.54***	0.57***
			(0.05)	(0.08)
Number of Observations	179	169	178	168
R^2	0.75	0.77	0.84	0.84

Notes: This table shows the results from regression (4). The observations are at a weekly frequency between 2007 and June 2010. The dependent variable is the swap-OAS (Bloomberg ticker: NOASFNCL.IND). The "Bond Spread" control variable captures the spread between five-year Fannie Mae bonds and U.S. Treasury active (on-the-run) securities (Bloomberg ticker: FNMGVN5.IND). "Total MBS Purchases" captures the stock of GSE-insured MBS held by the Federal Reserve and Treasury as a percentage of the total market of about $5 trillion. In columns 2 and 4 we instrument for the bond spread series with (i) the level of the Case-Shiller house-price index, (ii) the month-on-month change in this index, and (iii) the Moody's AAA bond index. Standard errors are in parentheses. Significance levels: *** ($p < 0.01$), ** ($p < 0.05$), * ($p < 0.1$).

higher-frequency series, we take the average of the observations for that week. The estimation period is the beginning of 2007 through June 2010.

In table 1 we report the regression results which show the impact of MBS purchases on the swap-OAS using the GSE debt spread as the control variable. We ran regression equation (4), with the swap-OAS as the dependent variable:

$$OAS_t = \alpha + \beta_1 * GSE\_Spread_t + \beta_2 * Total\_MBS\_Purchases_t + \varepsilon_t. \quad (4)$$

Recall that we do not need to proxy for prepayment risk, since this is already removed from the OAS series. In columns 1 and 2 we show the OLS and instrumental variable results. In columns 3 and 4 we also include the lagged value of the OAS series, to allow for

Table 2. Fannie Mae Swap-OAS Regressions with Subordinated Debt Spreads

	(1) OLS	(2) IV	(3) OLS	(4) IV
Bond Spread	0.24***	0.25***	0.08***	0.09***
	(0.01)	(0.01)	(0.02)	(0.03)
Total MBS Purchases	22.81**	7.81	3.84	−1.32
	(10.85)	(11.46)	(8.56)	(9.49)
OAS ($t-1$)			0.67***	0.63***
			(0.06)	(0.09)
Number of Observations	178	168	177	167
R^2	0.72	0.75	0.84	0.84

Notes: This table shows the results from regression (4) with the subordinated debt spread replacing the GSE bond spread. The observations are at a weekly frequency between 2007 and June 2010. The dependent variable is the swap-OAS (Bloomberg ticker: NOASFNCL.IND). The "Bond Spread" control variable captures the spread between Fannie Mae's Subordinated Benchmark Note series and five-year Treasuries (Bloomberg ticker: FNMA 4.625 05/01/13 Corp). "Total MBS Purchases" captures the stock of GSE-insured MBS held by the Federal Reserve and Treasury as a percentage of the total market of about $5 trillion. In columns 2 and 4 we instrument for the bond spread series with (i) the level of the Case-Shiller house-price index, (ii) the month-on-month change in this index, and (iii) the Moody's AAA bond index. Standard errors are in parentheses. Significance levels: *** ($p < 0.01$), ** ($p < 0.05$), * ($p < 0.1$).

the possibility that the effects of the purchases are distributed over time.

Observe in table 1 that the OAS moves closely with the bond spread, just as theory would predict: The OAS increases when the perceived probability of default increases. However, as measured by the coefficient on the MBS purchase volume, the impact of the purchases on the OAS was either significantly positive or insignificantly different from zero. In this specification there is no evidence that the increase in the MBS purchases led to a reduction in mortgage interest rate spreads as measured by this conventional OAS measure, once changes in default risk are controlled for.

Table 2 is analogous to table 1 except that we control for default risk using the subordinated debt series rather than the GSE debt

spread. Again, the coefficients on the total volume of MBS purchased are either positive or statistically insignificantly different from zero.

Another possible specification includes a dummy variable for whether or not there was an MBS purchase program along with the variable for the volume of purchases:

$$OAS_t = \alpha + \beta_1 * GSE\_Spread_t + \beta_2 * Total\_MBS\_Purchases_t + \beta_3 * I_{\{Program\ Event\},t} + \varepsilon_t. \quad (5)$$

The results are shown in table 3, which reports the effects of four different "program event" dummy variables. In each regression the dummy is set to 0 at the start of the sample period and then increased to 1 at a later date. In column 1 the dummy is set to 1 starting in September 2008, when the Treasury started buying MBS and Fannie and Freddie were taken into government conservatorship. In column 2 the dummy is set to 1 starting in January 2009, when the Federal Reserve purchases of MBS started. In column 3 the dummy is set to 1 starting with the announcement of the Federal Reserve's MBS purchase program on November 25, 2008. In column 4 we also consider the impact of the announcement of the program's expansion by the Federal Reserve on March 18, 2009. On this date it was announced that the Federal Reserve would more than double the size of the program, from $500 billion to $1.25 trillion.

The estimated coefficients in table 3 do not indicate that either the program's existence or the volume of purchases had a statistically significant negative effect on the swap-OAS. The coefficients are insignificant or positive.

To understand why the MBS program's volume or existence do not pick up an effect on the swap-OAS, it is useful to consider the residuals of regressions of the OAS series on the bond spread series (the risk indicator), without including the MBS explanatory variables. Figure 5 shows the residuals from such a regression for the swap-OAS series, along with the actual and predicted swap-OAS series over the sample period. Notice that the residuals through this whole period remain fairly evenly spread around zero. Movements in prepayment risk (as measured by swap-OAS) and default risk (as

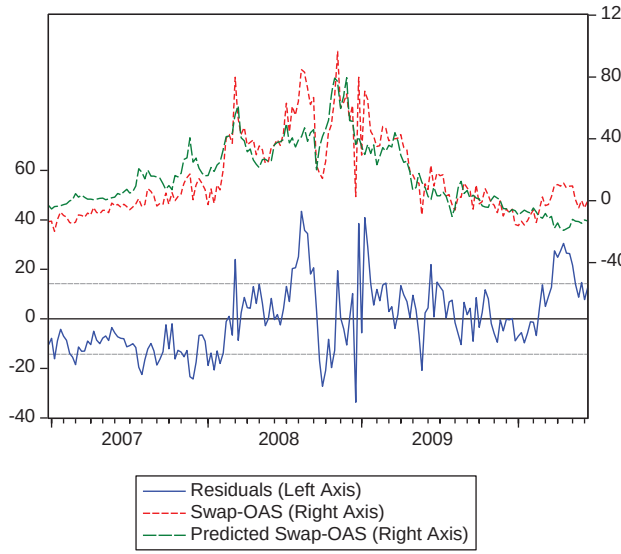
Table 3. Fannie Mae Swap-OAS with Program Dummies

	(1) Swap-OAS (Bloomberg)	(2) Swap-OAS (Bloomberg)	(3) Swap-OAS (Bloomberg)	(4) Swap-OAS (Bloomberg)
Bond Spread	0.88***	0.85***	0.85***	0.84***
	(0.05)	(0.04)	(0.04)	(0.04)
Total MBS Purchases	69.73***	24.58	31.22	63.47**
	(20.46)	(20.21)	(19.13)	(25.67)
MBS Treasury Dummy	−0.39			
	(3.45)			
MBS Federal Reserve Dummy		10.11***		
		(3.88)		
MBS Federal Reserve Announce			8.41**	11.14***
			(3.50)	(3.78)
MBS Federal Reserve Announce Expansion				−10.57*
				(5.66)
Number of Observations	179	179	179	179
R^2	0.75	0.76	0.75	0.76

Notes: This table shows the results from regression (5). The observations are at a weekly frequency between 2007 and June 2010. The dependent variable is the swap-OAS (Bloomberg ticker: NOASFNCL.IND). The "Bond Spread" control variable captures the spread between five-year Fannie Mae bonds and U.S. Treasury active (on-the-run) securities (Bloomberg ticker: FNMGVN5.IND). "Total MBS Purchases" captures the stock of GSE-insured MBS held by the Federal Reserve and Treasury as a percentage of the total market of about $5 trillion. In column 1 the program dummy is set to 1 starting in September 2008, when the Treasury started buying MBS. In column 2 the program dummy is set to 1 starting in January 2009, when the Federal Reserve purchases of MBS started. In column 3 the program dummy is set to 1 starting with the announcement of the Federal Reserve's MBS purchase program on November 25, 2008. In column 4 the additional "MBS Federal Reserve Announce Expansion" dummy is set to 1 at the MBS program expansion announcement on March 18, 2009. Significance levels: *** ($p < 0.01$), ** ($p < 0.05$), * ($p < 0.1$).

measured by agency debt spreads) account for the major movements in mortgage spreads. Little remains to be explained by the MBS purchases. This is the reason why the coefficient on MBS purchases is very small in the swap-OAS regressions.

Figure 5. Residual Analysis of Swap-OAS

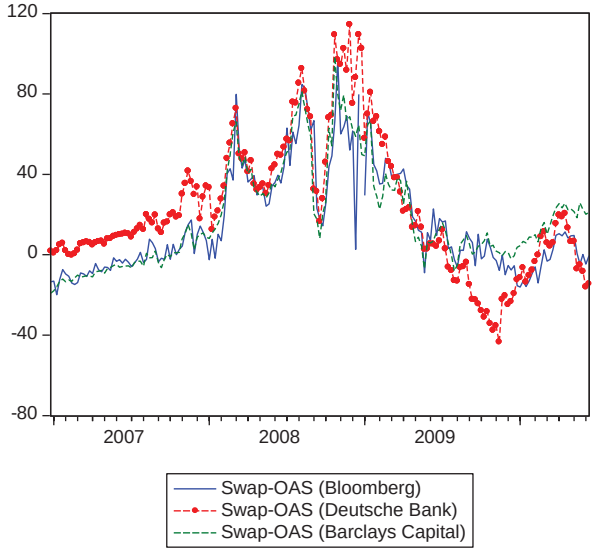


Notes: The swap-OAS line is the Bloomberg series NOASFNCL.IND. The predicted swap-OAS line shows the predicted values of a regression: $OAS_t = \alpha + \beta_1 * GSE\_Spread_t + \varepsilon_t$, where the GSE_Spread series is given by the spread between five-year Fannie Mae bonds and U.S. Treasury active (on-the-run) securities (Bloomberg series: FNMGVN5.IND). The residual series plots the residuals from the regression.

One possible concern with the analyses presented above is that the option-adjusted spread relies on the quality of the Bloomberg prepayment and interest rate models used to construct the OAS.[17] Below we present two robustness checks to the previous analysis. In the first robustness check we use two alternative swap-OAS series

[17]One might be concerned about this since during the crisis OAS calculations became particularly difficult to perform. Falling house prices and resulting negative home equity lowered the probability of refinancing, as did the tightening of lending standards and the market exit of a number of important mortgage lenders. This suggests that models that were not adequately updated would likely overstate the value of the prepayment option. In addition, during the crisis the dynamics of the swap curve and the Treasury curve might have changed, complicating the use of interest rate models that were calibrated to the pre-crisis economy.

Figure 6. Comparing Three Sources of Swap-OAS Spread



Notes: This figure compares the three swap-OAS series. The solid line represents an OAS series for Fannie Mae thirty-year current-coupon MBS computed by Bloomberg (Bloomberg ticker: NOASFNCL.IND). The dashed line with circles represents a swap-OAS series for a portfolio of agency MBS compiled by Deutsche Bank (Bloomberg ticker: Deutsche DBIQ US TBA MBS OAS Libor). The dashed line represents an OAS series for Fannie Mae thirty-year current-coupon MBS computed by Barclays Capital (retrieved through Barclays Live).

as dependent variables to remove prepayment risk. These alternative series were constructed using different interest rate and prepayment models. We use (i) an OAS series for thirty-year Fannie Mae current-coupon MBS computed by Barclays Capital and (ii) an OAS series for a monthly rebalanced index of agency MBS, compiled by Deutsche Bank (Bloomberg ticker: DBIQ US TBA MBS OAS Libor).[18] Figure 6 plots the two alternative OAS series and the Bloomberg OAS series. Up to the end of 2009, the Barclays and the Bloomberg OAS series co-moved very closely, suggesting that the

[18]This index includes MBS from Fannie Mae, Freddie Mac, and Ginnie Mae with durations of fifteen years or thirty years. It is described at https://index.db.com/htmlPages/MBS_Index_Guide_V.pdf.

models used by Bloomberg and Barclays Capital were rather similar (both series construct OAS for thirty-year Fannie Mae current-coupon MBS). However, during the last few months of the MBS program, the OAS series computed by Barclays rose significantly more, which implies that their model valued the prepayment option less than the Bloomberg model. The Deutsche Bank series does not capture the OAS of a single security, but of an index of MBS. Before the crisis, this OAS was higher than that of the thirty-year Fannie Mae current-coupon MBS. During the crisis, the co-movement with the MBS index provided by Bloomberg increased significantly.

In table 4 we repeat the key regressions from table 3 using the Barclays swap-OAS series. Notice that the coefficient on the total volume of MBS purchased by the Federal Reserve and Treasury is statistically significant and *positive*. This finding relative to the Bloomberg OAS-spread regressions is not surprising, since the Barclays OAS series increased at a faster rate than the Bloomberg OAS series during the first months of 2010, while the Federal Reserve continued to purchase more MBS during that period. The coefficients on the program announcements are negative; however, they are very small, and the net impact of the announcement effect and the volume effect is positive. Thus, results using this alternative OAS series do not provide any evidence that the Federal Reserve's MBS purchase program had an impact in reducing mortgage spreads, after controlling for prepayment risk and default risk.

In table 5 we present a similar set of regressions, using the OAS series provided by Deutsche Bank as the dependent variable. As before, none of the specifications suggest a significant reduction in option-adjusted spreads of agency MBS as a result of either the existence of the program or its volume, after we have controlled for changes in prepayment risk and default risk. This is highly consistent with the results found in table 4 using the Barclays OAS series.

A second set of robustness checks considers regressions where the secondary MBS market spread is the left-hand-side variable, without attempting to control for changes in prepayment risk. One interpretation of this is that the value of the prepayment option is assumed to be zero.[19] In addition, if the Federal Reserve's actions did

[19]Given that we argued in footnote 17 that model misspecification most likely led to an overvaluation of the prepayment option, this specification can provide a bound on the error resulting from valuing this option incorrectly.

Table 4. Fannie Mae Swap-OAS from Barclays Capital

	(1) Swap-OAS (Barclays)	(2) Swap-OAS (Barclays)	(3) Swap-OAS (Barclays)	(4) Swap-OAS (Barclays)
Bond Spread	0.97***	0.92***	0.90***	0.89***
	(0.05)	(0.04)	(0.04)	(0.04)
Total MBS	153.41***	150.74***	115.35***	195.62***
Purchases	(20.03)	(20.33)	(19.21)	(24.80)
MBS Treasury	−7.80**			
Dummy	(3.36)			
MBS Federal		−8.23**		
Reserve		(3.90)		
Dummy				
MBS Federal			0.05	6.32*
Reserve			(3.49)	(3.54)
Announce				
MBS Federal				−25.79***
Reserve				(5.43)
Announce				
Expansion				
Number of	180	180	180	180
Observations				
R^2	0.74	0.74	0.73	0.76

Notes: This table shows the results from regression (5). The observations are at a weekly frequency between 2007 and June 2010. The dependent variable is the OAS of Fannie Mae thirty-year current-coupon MBS as computed by Barclays Capital. The "Bond Spread" control variable captures the spread between five-year Fannie Mae bonds and U.S. Treasury active (on-the-run) securities (Bloomberg ticker: FNMGVN5.IND). "Total MBS Purchases" captures the stock of GSE-insured MBS held by the Federal Reserve and Treasury as a percentage of the total market of about $5 trillion. In column 1 the program dummy is set to 1 starting in September 2008, when the Treasury started buying MBS. In column 2 the program dummy is set to 1 starting in January 2009, when the Federal Reserve purchases of MBS started. In column 3 the program dummy is set to 1 starting with the announcement of the Federal Reserve's MBS purchase program on November 25, 2008. In column 4 the additional "MBS Federal Reserve Announce Expansion" dummy is set to 1 at the MBS program expansion announcement on March 18, 2009. Significance levels: *** ($p < 0.01$), ** ($p < 0.05$), * ($p < 0.1$).

Table 5. Swap-OAS from Deutsche Bank

	(1) Swap-OAS (Deutsche Bank)	(2) Swap-OAS (Deutsche Bank)	(3) Swap-OAS (Deutsche Bank)	(4) Swap-OAS (Deutsche Bank)
Bond Spread	0.84***	0.89***	0.84***	0.82***
	(0.07)	(0.06)	(0.06)	(0.04)
Total MBS	−38.93	2.74	−66.46***	83.34***
Purchases	(26.98)	(27.30)	(25.17)	(30.24)
MBS Treasury	3.88			
Dummy	(4.53)			
MBS Federal		−5.34		
Reserve Dummy		(5.24)		
MBS Federal			10.65**	22.36***
Reserve			(4.57)	(4.33)
Announce				
MBS Federal				−48.14***
Reserve Announce				(6.63)
Expansion				
Number of	180	180	180	180
Observations				
R^2	0.72	0.72	0.73	0.79

Notes: This table shows the results from regression (5). The observations are at a weekly frequency between 2007 and June 2010. The dependent variable is the OAS for a monthly rebalanced index, compiled by Deutsche Bank, that tracks the MBS TBA Market (Bloomberg ticker: DBIQ US TBA MBS OAS Libor). The "Bond Spread" control variable captures the spread between five-year Fannie Mae bonds and U.S. Treasury active (on-the-run) securities (Bloomberg ticker: FNMGVN5.IND). "Total MBS Purchases" captures the stock of GSE-insured MBS held by the Federal Reserve and Treasury as a percentage of the total market of about $5 trillion. In column 1 the program dummy is set to 1 starting in September 2008, when the Treasury started buying MBS. In column 2 the program dummy is set to 1 starting in January 2009, when the Federal Reserve purchases of MBS started. In column 3 the program dummy is set to 1 starting with the announcement of the Federal Reserve's MBS purchase program on November 25, 2008. In column 4 the additional "MBS Federal Reserve Announce Expansion" dummy is set to 1 at the MBS program expansion announcement on March 18, 2009. Significance levels: *** ($p < 0.01$), ** ($p < 0.05$), * ($p < 0.1$).

contribute to a decline in prepayment risk, we would like to measure this contribution to an overall decline in mortgage rates. In table 6 the specific dependent variable is the spread of the secondary market yield of thirty-year Fannie Mae MBS over the ten-year swap rate.

Table 6. Secondary Market Spread over Swap Rates

	(1) Secondary Market Spread	(2) Secondary Market Spread	(3) Secondary Market Spread	(4) Secondary Market Spread
Bond Spread	0.67***	0.74***	0.71***	0.71***
	(0.08)	(0.07)	(0.07)	(0.07)
Total MBS Purchases	−20.96	−49.65	−37.93	21.18
	(32.11)	(31.96)	(29.89)	(40.45)
MBS Treasury Dummy	12.89**			
	(5.40)			
MBS Federal Reserve Dummy		21.35***		
		(6.13)		
MBS Federal Reserve Announce			18.28***	22.89***
			(5.43)	(5.79)
MBS Federal Reserve Announce Expansion				−18.99**
				(8.86)
Number of Observations	180	180	180	180
R^2	0.51	0.53	0.53	0.54

Notes: This table shows the results from regression (5). The observations are at a weekly frequency between 2007 and June 2010. The dependent variable is the spread of Fannie Mae thirty-year current-coupon MBS (Bloomberg ticker: MTGEFNCL.IND) over ten-year swap rates. The "Bond Spread" control variable captures the spread between five-year Fannie Mae bonds and U.S. Treasury active (on-the-run) securities (Bloomberg ticker: FNMGVN5.IND). "Total MBS Purchases" captures the stock of GSE-insured MBS held by Federal Reserve and Treasury as a percentage of the total market of about $5 trillion. In column 1 the program dummy is set to 1 starting in September 2008, when the Treasury started buying MBS. In column 2 the program dummy is set to 1 starting in January 2009, when the Federal Reserve purchases of MBS started. In column 3 the program dummy is set to 1 starting with the announcement of the Federal Reserve's MBS purchase program on November 25, 2008. In column 4 the additional "MBS Federal Reserve Announce Expansion" dummy is set to 1 at the MBS program expansion announcement on March 18, 2009. Significance levels: *** ($p < 0.01$), ** ($p < 0.05$), * ($p < 0.1$).

The results are consistent with the findings using the option-adjusted spreads: The program dummies are positive, and the volume of purchases is never statistically significant. Again, after attempting to control for default risk using the bond spreads, it does not appear

Table 7. Fannie Mae Treasury-OAS Regressions with GSE Bond Spreads

	(1) OLS	(2) IV	(3) OLS	(4) IV
Bond Spread	0.89***	0.80***	0.40***	0.24***
	(0.06)	(0.06)	(0.06)	(0.09)
Total MBS Purchases	−143.73***	−184.18***	−57.70***	−68.55***
	(15.75)	(17.44)	(14.94)	(16.95)
OAS ($t-1$)			0.58***	0.66***
			(0.06)	(0.07)
Number of Observations	180	170	180	170
R^2	0.83	0.83	0.89	0.88

Notes: This table shows the results from regression (4). The observations are at a weekly frequency between 2007 and June 2010. The dependent variable is the Treasury-OAS (Bloomberg ticker: MOASFNCL.IND). The "Bond Spread" control variable captures the spread between five-year Fannie Mae bonds and U.S. Treasury active (on-the-run) securities (Bloomberg ticker: FNMGVN5.IND). "Total MBS Purchases" captures the stock of GSE-insured MBS held by the Federal Reserve and Treasury as a percentage of the total market of about $5 trillion. In columns 2 and 4 we instrument for the bond spread series with (i) the level of the Case-Shiller house-price index, (ii) the month-on-month change in this index, and (iii) the Moody's AAA bond index. Standard errors are in parentheses. Significance levels: *** ($p < 0.01$), ** ($p < 0.05$), * ($p < 0.1$).

as if the program significantly lowered secondary market spreads of agency-insured MBS.

3.2 Spreads over Treasury Rates

Tables 7 and 8 consider the same regressions as tables 1 and 2 except that Treasury-OAS replaces swap-OAS as the dependent variable. Here the sign of the coefficient on the MBS purchase volume shifts from positive to negative and statistically significant, indicating that the purchases have a negative effect on the Treasury-OAS. According to the estimated regression coefficient in column 2, a purchase of $500 billion worth of MBS (approximately 10 percent of the market) is associated with a reduction in the Treasury-OAS of 18.4 basis points.

Table 8. Fannie Mae Treasury-OAS Regressions with Subordinated Debt Spreads

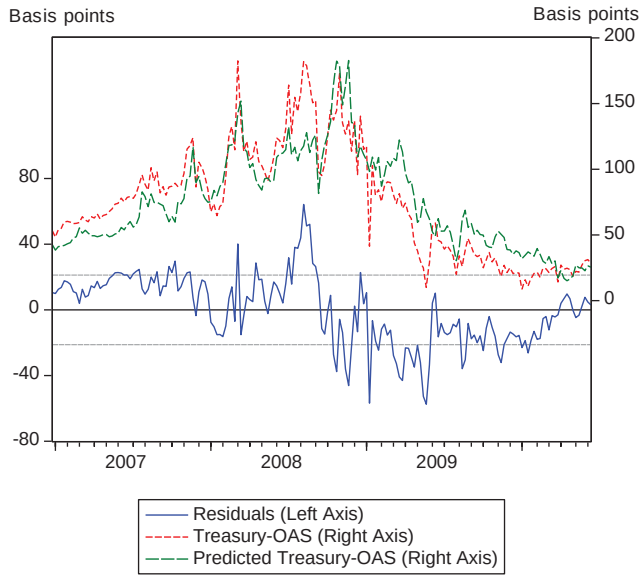
	(1) OLS	(2) IV	(3) OLS	(4) IV
Bond Spread	0.18***	0.17***	0.03*	0.02
	(0.02)	(0.02)	(0.02)	(0.02)
Total MBS Purchases	−216.02***	−247.82***	−56.03***	−62.89***
	(17.96)	(19.74)	(16.05)	(18.15)
OAS ($t-1$)			0.77***	0.79***
			(0.05)	(0.06)
Number of Observations	179	169	179	169
R^2	0.72	0.71	0.87	0.87

Notes: This table shows the results from regression (4). The observations are at a weekly frequency between 2007 and June 2010. The dependent variable is the Treasury-OAS (Bloomberg ticker: MOASFNCL.IND). The "Bond Spread" control variable captures the spread between Fannie Mae's Subordinated Benchmark Note series and five-year Treasuries (Bloomberg ticker: FNMA 4.625 05/01/13 Corp). "Total MBS Purchases" captures the stock of GSE-insured MBS held by the Federal Reserve and Treasury as a percentage of the total market of about $5 trillion. In columns 2 and 4 we instrument for the bond spread series with (i) the level of the Case-Shiller house-price index, (ii) the month-on-month change in this index, and (iii) the Moody's AAA bond index. Standard errors are in parentheses. Significance levels: *** ($p < 0.01$), ** ($p < 0.05$), * ($p < 0.1$).

To better understand this estimated effect of the program, figure 7 (which is analogous to figure 5 for the swap-OAS) shows the residuals from the regression of the Treasury-OAS on the default risk indicator. Here we see that the residuals are below zero for almost all of 2009, which is what is being picked up by the MBS purchase coefficient. However, note that the residuals show little trend movement throughout 2009, as the Federal Reserve's and the Treasury's MBS stock continuously grew in size. If the actual volume of purchases was a partial driving factor, we would expect residuals to become significantly more negative over time, as purchases expanded.

Rather, it appears as if there was a single downward shift in residuals without a further effect from conducting actual purchases. This suggests that the specification that includes program dummies might be superior. Table 9 introduces the same program dummies as table 3, using the Treasury-OAS as the dependent variable. The

Figure 7. Residual Analysis of Treasury-OAS



Notes: The Treasury-OAS line is the Bloomberg series MOASFNCL.IND. The predicted swap-OAS line shows the predicted values of a regression: $OAS_t = \alpha + \beta_1 * GSE\_Spread_t + \varepsilon_t$, where the GSE_Spread series is given by the spread between five-year Fannie Mae bonds and U.S. Treasury active (on-the-run) securities (Bloomberg series: FNMGVN5.IND). The residual series plots the residuals from the regression.

actual volume of the MBS held by the Federal Reserve and Treasury appears to have no statistically significant effect on the Treasury-OAS. However, unlike the swap-OAS regressions, the coefficient on the dummy variables in these regressions indicates an effect of the existence or the announcement of the MBS purchase program. The estimated coefficients imply a negative effect of about 30 basis points on the Treasury-OAS.

To examine the robustness of this finding, we looked at the secondary market spread over Treasuries. As shown in table 10, a regression with the spread of the Fannie Mae secondary market rate over constant-maturity ten-year Treasury rates also shows a statistically significant negative effect of the announcement of the program of about 30 basis points, without a significant further effect due to

Table 9. Fannie Mae Treasury-OAS with Program Dummies

	(1) Treasury-OAS (Bloomberg)	(2) Treasury-OAS (Bloomberg)	(3) Treasury-OAS (Bloomberg)	(4) Treasury-OAS (Bloomberg)
Bond Spread	1.16***	0.96***	0.99***	0.98***
	(0.06)	(0.05)	(0.05)	(0.05)
Total MBS Purchases	5.30	18.41	−20.53	54.05*
	(23.54)	(23.25)	(22.94)	(30.34)
MBS Treasury Dummy	−30.71***			
	(3.95)			
MBS Federal Reserve Dummy		−37.94***		
		(4.46)		
MBS Federal Reserve Announce			−28.31***	−22.49***
			(4.17)	(4.34)
MBS Federal Reserve Announce Expansion				−23.97***
				(6.65)
Number of Observations	180	180	180	180
R^2	0.87	0.88	0.86	0.87

Notes: This table shows the results from regression (5). The observations are at a weekly frequency between 2007 and June 2010. The dependent variable is the swap-OAS (Bloomberg ticker: NOASFNCL.IND). The "Bond Spread" control variable captures the spread between five-year Fannie Mae bonds and U.S. Treasury active (on-the-run) securities (Bloomberg ticker: FNMGVN5.IND). "Total MBS Purchases" captures the stock of GSE-insured MBS held by the Federal Reserve and Treasury as a percentage of the total market of about $5 trillion. In column 1 the program dummy is set to 1 starting in September 2008, when the Treasury started buying MBS. In column 2 the program dummy is set to 1 starting in January 2009, when the Federal Reserve purchases of MBS started. In column 3 the program dummy is set to 1 starting with the announcement of the Federal Reserve's MBS purchase program on November 25, 2008. In column 4 the additional "MBS Federal Reserve Announce Expansion" dummy is set to 1 at the MBS program expansion announcement on March 18, 2009. Significance levels: *** ($p < 0.01$), ** ($p < 0.05$), * ($p < 0.1$).

Table 10. Secondary Market Spread over Treasuries

	(1) Secondary Market Spread	(2) Secondary Market Spread	(3) Secondary Market Spread	(4) Secondary Market Spread
Bond Spread	1.14***	0.92***	0.95***	0.94***
	(0.06)	(0.05)	(0.05)	(0.05)
Total MBS	9.02	−14.83	−33.06	31.78
Purchases	(21.99)	(23.62)	(22.30)	(29.72)
MBS Treasury	−30.78***			
Dummy	(3.69)			
MBS Federal		−29.37***		
Reserve Dummy		(4.53)		
MBS Federal			−24.66***	−19.59***
Reserve Announce			(4.05)	(4.25)
MBS Federal Reserve				−20.83***
Announce Expansion				(6.51)
Number of Observations	180	180	180	180
R^2	0.88	0.87	0.86	0.87

Notes: This table shows the results from regression (5). The observations are at a weekly frequency between 2007 and June 2010. The dependent variable is the spread of Fannie Mae thirty-year current-coupon MBS (Bloomberg ticker: MTGEFNCL.IND) over ten-year U.S. Treasury yields. The "Bond Spread" control variable captures the spread between five-year Fannie Mae bonds and U.S. Treasury active (on-the-run) securities (Bloomberg ticker: FNMGVN5.IND). "Total MBS Purchases" captures the stock of GSE-insured MBS held by the Federal Reserve and Treasury as a percentage of the total market of about $5 trillion. In column 1 the program dummy is set to 1 starting in September 2008, when the Treasury started buying MBS. In column 2 the program dummy is set to 1 starting in January 2009, when the Federal Reserve purchases of MBS started. In column 3 the program dummy is set to 1 starting with the announcement of the Federal Reserve's MBS purchase program on November 25, 2008. In column 4 the additional "MBS Federal Reserve Announce Expansion" dummy is set to 1 at the MBS program expansion announcement on March 18, 2009. Significance levels: *** ($p < 0.01$), ** ($p < 0.05$), * ($p < 0.1$).

the volume of the program. This effect is very similar to the effect detected on the Treasury-OAS.[20]

[20]This suggests that any decline in the Treasury-OAS can be attributed more to changes in the default risk than to an increase in the value of the prepayment option.

3.3 Did the MBS Program Make the Implicit Guarantee More Explicit?

As another robustness check, we examined whether the absence of size effects and the presence of program effects on Treasury-OAS might be due to the program's mere existence signaling to the market that federal government guarantees of the GSEs had become more likely. If investors believed that the government would always bail out Fannie and Freddie, despite the lack of explicit "full faith and credit" insurance, mortgage spreads over Treasuries would not have increased in 2007 and 2008 nor have remained high after the federal government takeover. The fact that spreads were positive suggests that market participants attached some likelihood to the government not bailing out Fannie and Freddie (in addition to some differences in the liquidity of the two securities). By directly purchasing GSE debt and GSE-insured MBS, the Federal Reserve increased its own financial exposure to the GSEs, increasing the perceived strength of the guarantee. For a discussion of the public's perception of U.S. government guarantees for GSEs, see Passmore (2005).

To try and separate the impact that these "implicit guarantee" effects had on the OAS from possible effects related to a provision of liquidity to mortgage markets, we analyze the development of the option-adjusted spread on MBS that are guaranteed by Ginnie Mae. Ginnie Mae securities are the only MBS that are explicitly guaranteed by the full faith and credit of the U.S. government. If Fannie Mae OAS declined significantly more following the announcement of the MBS purchase program than Ginnie Mae OAS, then this is evidence for an "implicit guarantee" explanation of any observed decline in spreads.

In table 3 we analyzed the swap-OAS and in table 9 the Treasury-OAS of Fannie Mae securities. In tables 11 and 12 we repeat the same regressions but use the OAS on Ginnie Mae securities as the dependent variable.[21] As was the case with the swap-OAS on Fannie Mae MBS in table 3, when analyzing the swap-OAS of Ginnie Mae

[21]We use the NOASGNSF.IND series from Bloomberg for the swap-OAS on thirty-year Ginnie Mae–insured MBS, and the MOASGNSF.IND series for the Treasury-OAS series.

Table 11. Ginnie Mae Swap-OAS with Program Dummies

	(1) Swap-OAS	(2) Swap-OAS	(3) Swap-OAS	(4) Swap-OAS
Bond Spread	0.78***	0.87***	0.85***	0.85***
	(0.06)	(0.05)	(0.05)	(0.05)
Total MBS Purchases	24.25	12.22	12.34	−16.61
	(22.73)	(22.53)	(20.98)	(28.24)
MBS Treasury Dummy	16.19***			
	(3.83)			
MBS Federal Reserve Dummy		21.19***		
		(4.33)		
MBS Federal Reserve Announce			20.80***	18.34***
			(3.84)	(4.15)
MBS Federal Reserve Announce Expansion				9.50
				(6.23)
Number of Observations	179	179	179	179
R^2	0.71	0.72	0.73	0.73

Notes: This table shows the results from regression (5). The observations are at a weekly frequency between 2007 and June 2010. The dependent variable is the swap-OAS for Ginnie Mae securities (Bloomberg ticker: NOASGNSF.IND). The "Bond Spread" control variable captures the spread between five-year Fannie Mae bonds and U.S. Treasury active (on-the-run) securities (Bloomberg ticker: FNMGVN5.IND). "Total MBS Purchases" captures the stock of GSE-insured MBS held by the Federal Reserve and Treasury as a percentage of the total market of about $5 trillion. In column 1 the program dummy is set to 1 starting in September 2008, when the Treasury started buying MBS. In column 2 the program dummy is set to 1 starting in January 2009, when the Federal Reserve purchases of MBS started. In column 3 the program dummy is set to 1 starting with the announcement of the Federal Reserve's MBS purchase program on November 25, 2008. In column 4 the additional "MBS Federal Reserve Announce Expansion" dummy is set to 1 at the MBS program expansion announcement on March 18, 2009. Significance levels: *** ($p < 0.01$), ** ($p < 0.05$), * ($p < 0.1$).

MBS, we find an incorrectly signed effect. The coefficients suggest that the program announcement, program start, and program volume all contributed to an *increase* in the spread, while the effects of program volume are not statistically significant. When looking at the effects on the Treasury-OAS of Ginnie Mae MBS, we find effects

Table 12. Ginnie Mae Treasury-OAS with Program Dummies

	(1) Treasury-OAS	(2) Treasury-OAS	(3) Treasury-OAS	(4) Treasury-OAS
Bond Spread	0.93***	0.90***	0.90***	0.90***
	(0.06)	(0.05)	(0.05)	(0.05)
Total MBS Purchases	−73.79***	−54.45**	−71.85***	−66.20**
	(23.13)	(23.14)	(21.80)	(29.88)
MBS Treasury Dummy	−6.25			
	(3.89)			
MBS Federal Reserve Dummy		−11.62***		
		(4.44)		
MBS Federal Reserve Announce			−7.42*	−6.98
			(3.95)	(4.28)
MBS Federal Reserve Announce				−1.81
				(6.55)
Number of Observations	180	180	180	180
R^2	0.85	0.85	0.85	0.85

Notes: This table shows the results from regression (5). The observations are at a weekly frequency between 2007 and June 2010. The dependent variable is the Treasury-OAS for Ginnie Mae securities (Bloomberg ticker: MOASGNSF.IND). The "Bond Spread" control variable captures the spread between five-year Fannie Mae bonds and U.S. Treasury active (on-the-run) securities (Bloomberg ticker: FNMGVN5.IND). "Total MBS Purchases" captures the stock of GSE-insured MBS held by the Federal Reserve and Treasury as a percentage of the total market of about $5 trillion. In column 1 the program dummy is set to 1 starting in September 2008, when the Treasury started buying MBS. In column 2 the program dummy is set to 1 starting in January 2009, when the Federal Reserve purchases of MBS started. In column 3 the program dummy is set to 1 starting with the announcement of the Federal Reserve's MBS purchase program on November 25, 2008. In column 4 the additional "MBS Federal Reserve Announce Expansion" dummy is set to 1 at the MBS program expansion announcement on March 18, 2009. Significance levels: *** ($p < 0.01$), ** ($p < 0.05$), * ($p < 0.1$).

that are between one-third and one-half the size of the effect on the Fannie Mae Treasury-OAS.[22] The results thus suggest that at

[22]These results survive in a specification where we drop the total volume of MBS purchased from the regression.

least 50 percent of the observed fall in Treasury-OAS on mortgage-backed securities guaranteed by Fannie Mae could be attributed to the "implicit guarantee" effect. This leaves at most a decline of about 15 basis points to be explained by the MBS purchase program.

If this "implicit guarantee" effect is indeed a key channel through which the MBS purchases and GSE debt purchases affected mortgage spreads,[23] a significantly more straightforward way to achieve the same goal would have been to extend, formally and explicitly, the full faith and credit of the United States to Fannie and Freddie, in a similar fashion as it is already extended to Ginnie Mae. Moreover, if the implicit guarantee was the channel, then similar MBS purchase programs used in the future are not likely to have any impact on spreads.

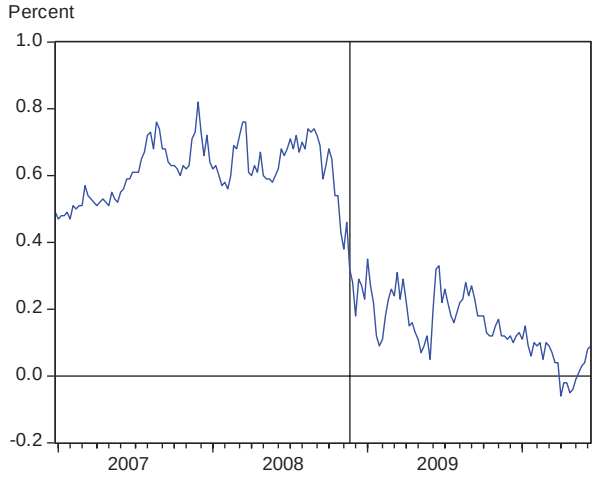
4. A Shift in the Swap Spread

The results in the previous section reveal a strong positive effect of risk factors and no negative effect of the *volume* of MBS purchases on mortgage spreads. These results are robust to alternative measures and specifications. The results also reveal a marked difference in the estimated effect of the MBS program's *existence* or *announcement* on spreads over swaps rates versus spreads over Treasury rates: Program dummies show no negative effect of the program on the swap-OAS and about a 30-basis-point negative effect on the Treasury-OAS. This result is also robust to alternative measures and specifications.

This difference in the estimated dummy coefficients in the regression equation for spreads over swaps versus spreads over Treasury rates implies certain relative movements of swaps and Treasury rates during this period. In particular, it implies that the spread between swaps rates and Treasury rates—commonly referred to as the *swap spread*—should have narrowed during this period. To show this simply, we can abstract from maturity differences or the term structure and let M = mortgage rate, S = swap rate, and T = Treasury rate. Then the two mortgage spreads discussed in the previous section are M-S and M-T, and the swap spread is S-T. Our empirical

[23] An "implicit guarantee" channel might also have contributed to the decline in the bond spreads, which we use to control for the default risk of the MBS.

Figure 8. Weekly Averages of the Ten-Year Swap Spread



Notes: This figure shows weekly averages of the difference between the ten-year swap rate and the ten-year constant-maturity Treasury rate. The vertical line is drawn for the week ending November 15, 2008.

results show that the M-S spread was unchanged during the period of the program (after controlling for prepayment and default risk), while the M-T spread decreased. So the implication is that (M-T) – (M-S) decreased, which means of course that the swap spread S-T decreased.[24]

In fact, the swap spreads did decrease during this period. We examined the one-year, two-year, five-year, and ten-year swap spreads. Figure 8 shows the ten-year swap spread, or the difference between the ten-year swap rate and the ten-year constant-maturity Treasury rate. Clearly there was a significant downshift in the swap spread during this time period. The spread averaged about 0.5 percent from 2005 through 2007 and about 0.1 percent from the start of 2009 through June 2011. The story is similar for the swap spreads at

[24]To consider the whole term structure, you can use the derivation of the OAS in equation (3). The interest rate (r_{it}) used for computing the OAS (θ) is based on the LIBOR swap curve in the case of the swap-OAS, while it is based on the Treasury yield curve in the case of the Treasury-OAS. The difference between these two curves is due to differences in the swap spreads at various maturities.

other maturities, though the shorter maturities increased by a larger amount during the panic in late September and early October 2008 before decreasing.[25]

The decline in the swap spread shown in figure 8 is well known to traders and investors in the swap and Treasury markets. The most commonly cited explanation[26] for the decline is the huge increase in Treasury borrowing relative to private-sector borrowing as the Federal deficit increased sharply when the economy went into a downturn in late 2008. This increased the demand for Treasury borrowing and decreased the demand for private-sector borrowing; hence, according to this explanation, the spread between swap rates and Treasury rates narrowed. In support of this explanation, the Treasury Borrowing Advisory Committee (2010) reported that until October 2008, the Treasury had been adding incrementally to coupon auction sizes. In October 2008, the Treasury surprised the market with $40 billion of 2015/18 issues, which was followed by a rapid rise in coupon issuance for a full year.

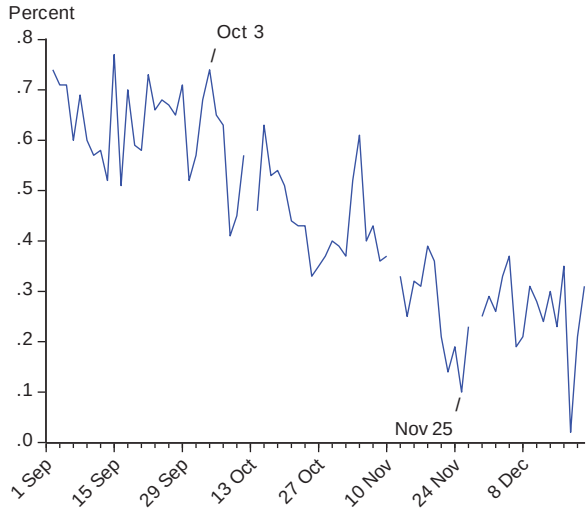
Given the algebraic link between the three spreads (M-S, M-T, and S-T), at least two possible explanations for the decline in the swap spread (S-T) thus emerge from our analysis. The first possible explanation—discussed in the previous section of this paper—is that the MBS program reduced mortgage spreads over Treasuries but did not reduce mortgage spreads over swaps and thereby led to a decline in the swap spread. The second explanation—discussed in the Treasury Borrowing Advisory Committee report (2010) and elsewhere—is that a large increase in the supply of Treasury debt drove down the swap spread and thereby created a differential between mortgage spreads over swap rates and mortgage spreads over Treasury rates.

There are potentially important timing differences which might help to distinguish between the two explanations. For example, the second explanation implies that the shift in the swap spreads would occur in October 2008 when Treasury issuance rose, while the first

[25]During the panic, the TED spread (three-month LIBOR over three-month Treasury-bill rates) and the LIBOR overnight index swap (OIS) spread were also spiking. See Smith (2010) and Taylor and Williams (2009) for a discussion of movements in LIBOR OIS around the period of the panic.

[26]See, for example, the quarterly Treasury Borrowing Advisory Committee report of May 2010.

Figure 9. Daily Observations on the Ten-Year Swap Spread in Late 2008



Notes: This figure shows daily observations on the difference between the ten-year swap rate and the ten-year constant-maturity Treasury rate.

explanation implies that the swap shift would begin at the time of the MBS program announcement or startup. In figure 8 we have drawn a vertical line at the week ending November 15, which was before the November 25 announcement of the Federal Reserve's purchase program. In figure 9 we show daily observations on that same swap spread. Most of the movement in the spread occurred before the announcement of the program by the Federal Reserve. While this provides some evidence in favor of the second hypothesis, rigorous testing between these two explanations will require additional research, including further specifying and exploring the second explanation, which is beyond the scope of this paper.

5. Conclusion

In this paper we endeavored to estimate the quantitative impact of the Federal Reserve's mortgage-backed securities purchase program

on mortgage interest spreads using a multivariate statistical framework which takes into account other possible influences on spreads. We controlled for two other possible influences on mortgage spreads: changes in prepayment risk and changes in default risk. Our results can be summarized as follows:

- Using conventional option-adjusted spreads (OAS) from Bloomberg based on LIBOR swaps to control for prepayment risks, it is difficult to detect a significant effect of the MBS purchases. Movements in prepayment risk and particularly movements in default risk explain virtually all of the movements in mortgage spreads, as captured by the OAS relative to the swap curve. We find similar results when using other swap-OAS series compiled by Barclays and Deutsche Bank, as well as when considering the secondary market MBS spread without controlling for possible changes in prepayment risk.
- A statistically significant effect on mortgage spreads—about 30 basis points—can be found if one uses an alternative measure of OAS based on the Treasury yield curve, but even with this measure the volume of purchases has no effect over and above the mere announcement or existence of the program. In other words, the impact has not increased with the additional purchases of MBS since the start of the program. We find a similar effect when we consider the secondary market MBS spread of MBS over Treasuries, without attempting to control for prepayment risk.
- When also analyzing the impact on the OAS of MBS guaranteed by Ginnie Mae, which has the U.S. government's explicit full faith and credit guarantee, we find evidence for the suggestion that about 50 percent of the 30-basis-points decline in Treasury-OAS for MBS guaranteed by Fannie Mae can be attributed to what we call the "implicit guarantee" effect. This suggests that about 15 basis points of the decline in Treasury-OAS can be explained by increased liquidity in agency-insured MBS markets.
- Finally we showed that the estimated negative impact on the Treasury-OAS compared with the estimated zero impact on the swap-OAS implies a downward shift in the swap spread or the difference between swap rates and Treasury rates during

this period. Such a shift did indeed occur and has been noted by market participants, who have offered an explanation unrelated to the MBS purchase program. While timing differences provide support for this alternative explanation, further research is required to discriminate rigorously between these hypotheses. We hope that the information in this study will be of value in such research.

Analyzing the effectiveness of the MBS purchase program is very difficult. The creation of adequate counterfactuals is complicated by the simultaneous government interventions in a large number of markets. Furthermore, the conservatorship status of the GSEs has contaminated many of the relevant GSE default risk proxies that are most important to control for when analyzing the development of spreads on GSE-insured MBS. Our analysis has used a variety of different approaches to proxy for this risk, each with its own problems. Nevertheless, on balance this paper suggests that the impact of the Federal Reserve's MBS purchase program on mortgage spreads has been small and uncertain, once the effects of default risk and prepayment risk have been taken into account.

While this paper is unlikely to be the final word on the program's effectiveness, our empirical results thus raise questions about the ability of central banks to conduct price-keeping operations reliably by increasing and decreasing asset purchases in particular markets. They also raise doubts about the benefits in terms of lower mortgage interest rates of further increases in the size of the Federal Reserve's MBS portfolio or about the costs in terms of higher interest rates of gradually reducing the size of that portfolio.

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