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Diana Hancock and Wayne Passmore

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DID THE FEDERAL RESERVE'S MBS PURCHASE PROGRAM LOWER MORTGAGE RATES?

Diana Hancock and Wayne Passmore[ψ]
Board of Governors of the Federal Reserve System
Washington, DC 20551

ABSTRACT

We employ empirical pricing models for mortgage-backed security (MBS) yields and for mortgage rates to measure deviations from normal market functioning in order to assess how the Federal Reserve MBS purchase program—a 16 month program announced on November 25, 2008 and completed on March 31, 2010—affected risk premiums that were embedded in mortgage and swap markets. Our pricing models suggest that the announcement of the program, which signaled strong and credible government backing for mortgage markets in particular and for the financial system more generally, reduced mortgage rates by about 85 basis points between November 25 and December 31, 2008, even though no MBS had (yet) been purchased by the Federal Reserve.

Once the Federal Reserve's MBS program started purchasing MBS, we estimate that the abnormal risk premiums embedded mortgage rates decreased roughly 50 basis points. However, observed mortgage rates declined only slightly because of generally rising interest rates.

After May 27, 2009 fairly normal pricing conditions existed in U.S. primary and secondary mortgage markets; that is, the relationship between mortgage rates and its determinants was similar to that observed prior to the financial crisis. After the end of the Federal Reserve's MBS purchase program on March 31, 2010, mortgage rates and interest rates more generally were significantly less than they had been at the beginning.

In sum, we estimate that the Federal Reserve's MBS purchase program removed substantial risk premiums embedded in mortgage rates because of the financial crisis. The Federal Reserve also re-established a robust secondary mortgage market, which meant that the marginal mortgage borrower was funded by the capital markets and not directly by the banks during the financial crisis—had bank funding been the only source of funds, primary mortgage rates would have been much higher.

Lastly, many observers have attributed part of the Federal Reserve's effect from purchasing MBS to portfolio rebalancing. We find that if portfolio rebalancing had a substantial effect, it may have had its greatest importance only after the Federal Reserve's purchases ended, but while the Federal Reserve held a substantial portion of the stock of outstanding MBS.

[ψ] Diana Hancock and Wayne Passmore a Deputy Associate Director and an Associate Director in the Division of Research and Statistics at the Board of Governors of the Federal Reserve System, respectively. The results in this paper are preliminary materials circulated to stimulate discussion and critical comment. The analysis and conclusions set forth are those of the authors and do not indicate concurrence by other members of the research staff or the Board of Governors. References in publications to this paper should be cleared with the authors. The authors thank Marvin Goodfriend, Burton Hollifield, Shane Sherlund, participants at the Carnegie-Rochester Conference on Public Policy's "Normalizing Central Bank Practice in Light of the Credit Turmoil, and seminar participants at the Federal Reserve Banks of Atlanta, and at the Federal Reserve Bank of New York for their useful comments. We also thank Owen Hearey and Benjamin J. Unterreiner for their excellent research assistance.

1. INTRODUCTION

On Tuesday, November 25, 2008 the Federal Reserve surprised almost everyone when it announced that it would initiate a program to purchase up to $500 billion in mortgage-backed securities (MBS) backed by the housing-related government-sponsored enterprises (GSEs), Fannie Mae and Freddie Mac, and backed by Ginnie Mae.[1] The goal of this new program was to "reduce the cost and increase the availability of credit for the purchase of houses."[2]

There is, of course, a disparity between rates in mortgage secondary markets (i.e., MBS yields) and the rates paid by homeowners to purchase houses in the primary mortgage market. This paper is focused on the question: "Did the Federal Reserve MBS purchase program lower mortgage rates?"

We use empirical pricing models for MBS yields in the secondary mortgage market and for mortgage rates paid by homeowners in the primary mortgage market to measure how distorted mortgage markets were prior to the Federal Reserve's intervention, and the course of market risk premiums during the restoration to normal market functioning. We also use this measure to assess if either MBS yields or mortgage rates were significantly lower than would be expected; this measure may indicate if investors faced a shortage of longer-term non-Treasury financial assets.

We argue that this return to normal pricing occurred because the Federal Reserve's announcement signaled a strong and credible government backing for mortgage markets in

[1] The U.S. Department of Treasury had already started a modest MBS purchase program. Its program was announced as an expression of support for Fannie Mae and Freddie Mac when these two GSEs were placed into government conservatorship on September 5, 2008.

[2] See http://www.federalreserve.gov/newsevents/press/monetary/20081125b.htm.

particular and for the financial system more generally. Moreover, the Federal Reserve's purchases were expected to have a "portfolio rebalance effect" derived from the withdrawal of relatively safe fixed-rate assets from investors' portfolios and a reduction in the demand for interest rate swaps used to hedge interest rate risks on MBS portfolios.[3] However, we find this effect to be relatively small during the program. However, the steep decline in mortgage rates after the end of the MBS purchase program may have been enhanced by the "stock effect" of the Federal Reserve's purchases.

More specifically, we estimate that the Federal Reserve's MBS purchase program over the course of 16 months reestablished normal market pricing in the MBS market and resulted in lower mortgage rates of roughly 100 to 150 basis points for purchasing houses.[4] Most of the decline in mortgage rates occurred between the announcement of the program, on November 25, 2008, and the implementation of the program in the first quarter of 2009. After this point, both mortgage rates and risk premiums remained relatively stable until the end of the Federal Reserve MBS purchase program. However, there was a substantial

[3] The "portfolio balance" effect works as follows: (1) when the Federal Reserve purchases an asset, it reduces the amount of the security that the private sector holds, while simultaneously increasing the amount of short-term, risk-free, bank reserves held by the private sector, (2) in order to induce private sector investors to adjust their portfolios (i.e., reduce their holdings), the expected return on the asset must fall (i.e., the purchases bid up the price of the asset and lower its yield). This pattern is described in Tobin, J., 1958, "Liquidity Preference as Behavior Towards Risk," *Review of Economic Studies*, 25, pp. 124-131. See also Gagnon, J., M. Raskin, J. Remache, and B. Sack, 2010, "Large Scale Asset Purchases by the Federal Reserve Did They Work? *Federal Reserve Bank of New York Staff Reports*, no. 441, March.

[4] There are currently three working papers that consider the effects of the Federal Reserve's MBS purchase program: (1) Andreas Fuster and Paul Willen, 2010, "$1.25 Trillion is Still Real Money: Some Facts about the Effects of the Fed's Mortgage Market Investments," *Federal Reserve Bank of Boston Public Policy Discussion Papers*, No. 10-4, (2) Johannes Stroebel and John Taylor, 2010, "Estimated Impact of the Fed's Mortgage-Backed Securities," mimeo, October, and (3) Joseph Gagnon, Matthew Raskin, Julie Remache and Brian Sack, 2010, "Large Scale Asset Purchases by the Federal Reserve: Did They Work?," *Federal Reserve Bank of New York Staff Reports*, no. 441, March. Each of these papers uses a different empirical technique to determine the effects of the Federal Reserve's purchase program. All of the papers find evidence of substantial announcement effects for the program, with estimates for the decline in interest rates ranging from 30 basis points to slightly over 100 basis points.

decline in interest rates during the months following the end of the purchase program, part of which might be attributed to the "stock effect" of the Federal Reserve's holdings.

The remainder of this paper is structured as follows: Section 2 provides a brief description of mortgage markets during the autumn of 2008, when the Federal Reserve's MBS program was announced, through early 2010, when the program was wound down. Section 3 provides a brief historical account of the intervention period that contains three distinct intervals—one associated with the announcement, another associated with uncertainty about the intent of government actions, and one that brought the return to normal market pricing conditions. Section 4 presents our secondary market and primary market mortgage pricing models and our time-series estimates of the effects of the Federal Reserve's mortgage-backed securities program on mortgage rates. Section 5 provides the conclusion.

2. THE STRUCTURE OF THE U.S. SECONDARY MORTGAGE MARKET: LATE-2008 THROUGH EARLY 2010

When a homeowner finances a home with a 30-year fixed-rate conforming mortgage, he (she) has the option to prepay his (her) mortgage. This option is implicitly paid for by the homeowner with an upward adjustment in the mortgage rate. However, the provider of the mortgage has to estimate how much to increase the mortgage rate to cover the costs associated with this prepay option, and thereby has to estimate when the homeowner is likely to prepay the mortgage.

Suppose a mortgage is incorporated into an agency MBS. In the event that the homeowner prepays the mortgage, the cash payment is sent to the holders of the agency MBS on a pro-rata basis. Although the holders of the MBS are uncertain about when such a pre-payment will be received, the pre-payment is more likely when mortgage rates are lower.

Investors adjust the stated yields on MBS for the homeowner's prepayment option when comparing yields across fixed-rate securities. This "option-adjusted spread," or OAS, is the additional return from holding an MBS relative to a benchmark, such as a swap rate or a Treasury yield.

OAS is usually derived from computer simulations that attempt to model the propensity of homeowners to prepay their mortgage when current mortgage rates are low compared with previous mortgage rates. Homeowners are more likely to refinance their mortgage in low rate environments, with the result that the investor receives cash at exactly the wrong time—just when reinvestment possibilities all provide low returns.

During 2009, such OAS calculations became difficult and unreliable. With declining home values and fears about how high unemployment would affect both mortgage delinquencies and default, homeowners' propensity to prepay became very difficult to model and predict. Without the ability to reliably estimate prepayment speeds, the duration of MBS holdings became difficult to predict.

More specifically, duration is the change in the market value of MBS as interest rates change. When interest rates become higher, the value of MBS declines because other bonds pay higher rates and because the effective maturity of the security extends in a relatively high rate environment because homeowners are less likely to prepay their mortgage. When interest rates become lower, the likelihood of prepayments by homeowners with fixed-rate mortgages rises, and the value of MBS will reflect refinancing and home sale decisions.

During 2009, the lack of homeowner refinancings of mortgages in response to low interest rates (primarily due to rising refinancing costs, homeowners' declining home equity, and homeowners' deteriorating financial conditions) repeatedly surprised MBS market participants and lengthened (that is, raised) their estimates of duration. All things equal,

during 2009 relatively high coupon MBS increased in value because of these rising estimates of duration, and newer and lower yielding MBS became viewed as much longer-lived assets and consequently more volatile financial instruments. The additional volatility in the market value of the new and lower yielding coupon MBS meant that hedging such instruments became more expensive and also less reliable.

THE DEMAND FOR GSE MBS

Even under normal market conditions, when the Federal Reserve (over time) committed to purchasing $1.25 trillion of MBS by the end of the first quarter of 2010, it would have become the largest "buy-and-hold" investor in MBS. But during the autumn of 2008, a period of severe financial market turmoil and a deep recession, private sector buyers of MBS were on the sidelines. Moreover, the Federal Reserve's MBS purchases far outpaced net MBS issuance throughout the period of its purchase program because the refinancing of mortgages and new home sales remained relatively weak in spite of the low level of mortgage rates. In short order, the Federal Reserve became the dominant player in the secondary mortgage market.

Up until the autumn of 2008, the major players in the MBS market were the two housing-related GSEs (Fannie Mae and Freddie Mac), depository institutions, foreign buyers (including central banks and sovereign wealth funds), and money managers. Among these players, the GSEs had typically operated with the lowest funding costs.

GSEs: Fannie Mae and Freddie Mac. On September 7, 2008, the Federal Housing Finance Agency (FHA) placed Fannie Mae and Freddie Mac into conservatorship. At the same time, Treasury took three additional steps to complement FHFA's decision to place both enterprises in conservatorship. First, Treasury and FHFA established Preferred Stock

Purchase Agreements—contractual agreements between the Treasury and the conserved entities—to ensure that each company would maintain a positive net worth. Second, Treasury established a new secured lending credit facility that would be available to Fannie Mae, Freddie Mac, and the Federal Home Loan Banks, thereby implementing the temporary liquidity backstop authority that had been granted by Congress in the previous July. This backstop would be available until those authorities expired in December 2009. Third, to further support the availability of mortgage financing, Treasury initiated a temporary program to purchase GSE MBS. When announcing the Treasury's GSE MBS program, Secretary Paulson stated: "As the GSEs have grappled with their difficulties, we've seen mortgage rate spreads to Treasuries widen, making mortgages less affordable for homebuyers. While the GSEs are expected to moderately increase the size of their portfolios over the next 15 months through prudent mortgage purchases, complementary government efforts can aid mortgage affordability."[5] The Treasury's GSE MBS program began later in September 2008 and expired with the Treasury's temporary authorities in December 2009.

Depository Institutions. Banks and other depository institutions have tended to compare MBS yields to their own loan yields. During a recession, GSE MBS had traditionally been a "parking spot" for banks' excess funding while they waited for clearer signals concerning loan demand. More specifically, when MBS yields rose relative to loan yields, and loan demand remained subdued, then banks stepped-up their MBS purchases.

But the recession that began in December 2007 was atypical. By autumn 2008, some banks were facing capital constraints that limited their ability to increase their MBS purchases. Moreover, to enhance their capitalization, such banks had an incentive to sell

[5] See Paulson, H.M, 2008, "Statement by Secretary Henry M. Paulson, Jr. on Treasury and Federal Housing Finance Agency Action to Protect Financial Markets and Taxpayers," HP-1129, September 7, which is available at: http://www.ustreas.gov/press/releases/hp1129.htm.

their MBS holdings when OAS spreads were falling, in order to book capital gains and build their capital. Indeed, with bank capital in short supply, some banks found it appealing to purchase Ginnie Mae securities (with a zero risk-weight in regulatory capital calculations), rather than Fannie Mae or Freddie Mac securities (with a 20 percent risk-weight in regulatory capital calculations).

Foreign Buyers. Foreign buyers, including central banks and sovereign wealth funds, greatly curtailed or ceased their purchases of GSE MBS in the months leading up to the establishment of the GSE conservatorships in September 2008. Afterwards, in the face of persistent dollar accumulations, they occasionally entered the MBS market, but persistent uncertainty about the future of Fannie Mae and Freddie Mac put these foreign institutions "on-hold," and they generally limited any increases in their U.S. dollar dominated assets to U.S. Treasury securities.

Money Managers. The money managers who participate in bond markets on behalf of themselves and others usually compare the relative return on holding GSE MBS to holding other forms of fixed-income securities. These investors did not make large purchases of GSE MBS during the Federal Reserve MBS purchase program. The relatively low level of MBS option-adjusted spreads, OAS, during (and after) the Federal Reserve's MBS purchase program meant that their attention turned elsewhere.

Looking back to December 31, 2009, the total outstanding MBS that were backed by Fannie Mae and Freddie Mac together totaled roughly $3.9 trillion.[6] These entities each held about $850 billion of their own MBS. Depository institutions held about $1.3 trillion in GSE MBS. Foreign entities' held about $600 billion in GSE MBS. Insurance companies, mutual

[6] The amounts of MBS backed by each GSE were not equal. Fannie Mae backed about $2.4 trillion of MBS and Freddie Mac backed about $1.5 trillion MBS.

funds, pension funds, and state governments held about $2.5 trillion in both agency debt and MBS.[7] Given these holdings by the other major players in the GSE MBS markets, the Federal Reserve's purchase of $1.25 trillion agency MBS would amount to approximately 32 percent of the outstanding agency MBS at year-end 2009. Because of the sheer magnitude of its MBS purchase program, there is no doubt that the Federal Reserve became the predominant purchaser of MBS during its purchase program.

THE SUPPLY OF GSE MBS AND MORTGAGE RATE DETERMINATION

When a bank (or other type of entity) originates a mortgage that is eligible for GSE securitization, it must decide whether to (1) bear the credit risk of the mortgage itself (i.e., hold the mortgage in its own portfolio), or (2) have a GSE guarantee the mortgage by converting the mortgage into MBS. If a bank converts the mortgage into GSE MBS, then it must also decide whether to hold the MBS in its portfolio or sell the MBS into the secondary market. For this second decision, the bank compares its return from holding GSE MBS on its balance sheet—funding it at a cost equal to its weighted average cost-of-funds, which consists mainly of FDIC insured deposits, Federal Home Loan Bank advances, and an imputed cost to equity—to the return it receives from selling the GSE MBS to another GSE MBS secondary market purchaser. In essence, the bank compares its own marginal cost of funds to that of the marginal cost of funds for the marginal secondary market purchaser of GSE MBS.[8]

[7] Unfortunately, the dollar amount for holdings by insurance companies, mutual funds, pension funds, and state governments cannot easily be parsed into GSE MBS holdings versus agency debt holdings or into separate financial sectors. That said, it appears that between one-half and one-third of the total dollar amount, $2.5 trillion, was held in MBS.

[8] For details of this model see A. Heuson, S.W. Passmore, and R. Sparks, 2001, "Credit Scoring and Mortgage Securitization: Implications for Mortgage Rates and Credit Availability," *Journal of Real Estate Finance and Economics*, Vol. 23, November, pp. 337-363, or D. Hancock and S.W. Passmore, 2010, "An Analysis of

Consequently, to actually influence the primary conforming mortgage rate, a GSE MBS purchaser must change the economic calculations associated with the mortgage originator's two decisions described above. The purchases of GSE MBS in the secondary market that were made by the Federal Reserve and by the U.S. Department of the Treasury were passive, that is, the MBS were purchased at prevailing market prices. Such purchases removed supply from the secondary market, with the hope of causing banks and other private market purchasers of MBS to bid more aggressively for the remaining MBS in the marketplace. Thus, Federal Reserve MBS purchases in the secondary market would influence primary mortgage rates only to the extent that (1) the secondary market itself was providing the marginal funding of primary mortgages and (2) the lower yields on current coupon MBS were effectively determining the primary mortgage rate.

With regard to the first condition, the secondary market was indeed the likely source of marginal funding during the recent financial crisis. During that period, the spread between the mortgage rate and Treasury rate increased substantially, in part because large bank originators were exercising increased caution. Originators were facing greater uncertainty with regard to holding the mortgages they originated. The interest rate risks associated with the mortgages was very uncertain in this unusual environment, with very low prepayments expected if mortgage rates increased and very high prepayments expected if mortgage rates fell. Finally, the cost of capital was very high for mortgage originators. For all these reasons, capital-starved mortgage originators likely had very high marginal costs if they decided to hold their newly originated mortgages in their own portfolios.

Government Guarantees and the Functioning of Asset-Backed Securities Markets, Federal Reserve Financial and Economic Discussion Series (FEDS), No. 2010-46, August.

Against this backdrop, failure had become epidemic among mortgage originators. During 2008 for example, more than 100 mortgage companies failed. And during 2008, three of the top eight mortgage lenders—Countrywide, Washington Mutual, and Wachovia—were acquired by their rivals.[9] Any expansion of mortgage origination capacity during the financial crisis was difficult because the remaining (and few) non-bank originators faced significant financing constraints and tremendous uncertainty about future mortgage demand. To sum up, capital was fleeing the traditional bank business of originating and holding mortgages, so a functioning government-backed secondary mortgage market was instrumental for financing mortgages during the financial crisis that began in 2007.

With regard to the second condition, the Federal Reserve's strategy of creating a shortage of "current coupon MBS" and thereby promoting housing market activity by lowering mortgage rates was expected to be difficult to achieve for at least three reasons: First, the Federal Reserve could only purchase agency- and Ginnie Mae-backed MBS and many recent mortgage borrowers had mortgages that were outside of the (revised) GSE and FHA underwriting standards. Such borrowers would continue to find it difficult to refinance their mortgages and thus they might not benefit from lower mortgage rates.

Second, as mortgage rates decline, mortgage refinancings by households usually increase. But such a refinancing wave could result in many "high coupon" agency MBS being prepaid and refinanced into "current coupon" MBS. In theory, this process could curb any shortage in current coupon MBS that would be created by the Federal Reserve's MBS purchases. Analogously, mortgage originations would likely increase with lower mortgage rates, and thereby create additional MBS supply. Such an origination cycle might have

[9] In January 2008, Bank of America bought Countrywide for $4.1 billion in stock. In September 2008, JP Morgan Chase announced it had acquired the deposits, assets, and certain liabilities of Washington Mutual in a transaction facilitated by the Federal Deposit Insurance Corporation. And in October 2008, Wachovia made an agreement to be acquired by Wells Fargo & Company for $15.1 billion in stock.

created a need for the Federal Reserve to purchase an ever larger quantity of MBS just to hold MBS spreads constant. (In practice, neither the refinancing wave nor the origination cycle became a significant source of mortgage supply during the recent financial crisis because of rising unemployment and falling house prices.)

Third, the segmentation in the market between current coupon MBS and other higher coupon MBS was imperfect. If MBS market investors found a shortage of current coupon MBS, many such investors could simply substitute to higher coupon MBS. *Ex ante*, the elasticity of this potential substitution across different coupons was unknown.

For all these reasons, the Federal Reserve's MBS purchases would likely need to be very big relative to the size of the secondary market in order to measurably lower the primary mortgage rate. Moreover, it might be difficult using the tools that were available to the Federal Reserve to influence the banking system's marginal cost of lending to conforming mortgage borrowers. Hence, it is an empirical matter whether the Federal Reserve's large purchases of GSE MBS actually had a significant effect on primary mortgage rates.

3. A DESCRIPTION OF THE FEDERAL RESERVE'S GSE MBS MARKET INTERVENTION

The large-scale GSE MBS purchase program was an integral component of the "credit easing" by the Federal Reserve, which focused on using the asset side of the central bank's balance sheet to eliminate illiquidity and abnormally high credit spreads in financial markets.[10] Federal Reserve MBS purchases were mostly securities issued by Fannie Mae and

[10] Credit easing involves expansion of the Federal Reserve's balance sheet with a focus on the mix of loans and securities it holds and an attention to how this composition will affect credit conditions for households and businesses. For a discussion of credit easing versus quantitative easing, see Bernanke, B.S., 2009, "The Crisis and the Policy Response," Remarks at the Stamp Lecture, London School of Economics, London, England, January 13 available at http:/www.federalreserve.go/newsevents/speech/bernanke20090113a.htm.

Freddie Mac. Ginnie Mae securities, with explicit full faith and credit government guarantees, were generally not the focus of Federal Reserve MBS purchases.

As shown in the top panel of figure 1, the Federal Reserve generally purchased between four and six billion dollars of agency MBS per day until the announcement of the end of the program on September 23, 2009. After that date, the purchases tapered off to a range on the order of two to three billion dollars of agency MBS per day. These purchases were implemented in a rather mechanical manner, with the average amount purchased during each day targeted to hit the desired total quantity of MBS holdings target by the last day of the MBS purchase program.

As shown in the middle panel of figure 1, Federal Reserve purchases accounted for between 50 and 150 percent of the gross issuance amount of current-coupon agency MBS that were issued by Fannie Mae, Freddie Mac, and Ginnie Mae. Since net issuance ran between one-third and one-half of gross issuance during the time period that is depicted (because of prepayments and repayments of mortgage principle amounts), the Federal Reserve generally purchased substantially more than the net MBS issuance amount. Indeed, the supply of "floating" MBS—the MBS that could be traded because it was not held in the portfolios of "buy and hold" investors—that was available to private sector market participants generally declined throughout the period. As shown in the bottom panel of figure 1, Federal Reserve agency MBS purchases eventually amounted to about one-third of all outstanding agency MBS.

Turning to the time-series information shown in figure 2, we argue that the Federal Reserve intervention period contains three distinct intervals—one associated with the announcement, another associated with uncertainty about the intent of government actions, and one that brought the return to normal market pricing conditions. In this figure, and

remaining figures, a vertical brown marker is used to indicate the announcement date: Tuesday, November 25, 2008.

ANNOUNCEMENT PERIOD

At the time of the announcement of the Federal Reserve MBS purchase program, mortgage market analysts generally praised it. They argued that it was a needed statement of support for a market that was supposedly already government-backed (but not acting like it). The Federal Reserve's program was applauded by market participants because it would potentially help resolve persistent problems associated with illiquidity, price discovery, and ambiguity about government guarantees in the secondary mortgage market. Moreover, the Federal Reserve's announcement lessened increasing market unease about the potential ramifications on the mortgage market that would result from (1) the constraints on the sizes of Fannie Mae's and Freddie Mac's portfolios that were imposed when these entities entered into their conservatorships, and (2) the significant and sharply increasing delinquency rates on the GSEs' mortgage holdings.[11]

Within minutes of the Federal Reserve's announcement, the Fannie Mae option-adjusted current coupon mortgage-backed security spreads (OAS) over swap yields plummeted from about 65 basis points to almost zero (not shown). And by the end of the day on November 25, profit takers had entered the market and were selling MBS in large quantities. As a result, the option-adjusted spread (over swap yields) was 37 basis points lower than the previous day.[12] At the same time, press reports indicated that mortgage rates

[11] The rate of loans 90 or more days past due in Fannie Mae's portfolio rose to 1.72 percent in September 2008 (the latest data available at the time of the Federal Reserve MBS purchase program announcement), up from 1.57 percent in the previous month. The single-family delinquency rate for Freddie Mac was 1.34 percent in October 2008, up from 1.22 percent in September 2008.

[12] Option-adjusted spreads over Treasury yields closed about 40 basis points lower than the previous day.

for prime borrowers (that is, borrowers of good credit quality with a 20 percent or larger down-payment) fell by as much as half of a percentage point. Indeed, this immediate (and significant) effect on mortgage rates likely resulted from expectations by market participants that the Federal Reserve would act to re-establish a functioning secondary mortgage market in which primary mortgage market originators would be able to finance their mortgages—at the margin—with certainty. These lower mortgage rates, in turn, set off a burst of mortgage refinancing activity by homeowners.

Because consultation with market participants was necessary to work out the operational details of the Federal Reserve MBS purchase program, there was a fairly long delay between the announcement of, and implementation of, the Federal Reserve's intervention into MBS markets. As a result, the Federal Reserve did not actually begin purchasing MBS until the first weeks of January 2009.[13] As shown in the top panel of figure 2, mortgage rates and MBS yields fell about 100 basis points over the announcement period.

As an indicator of risk premiums in the mortgage market, we present the spread between the current coupon agency MBS yield and a comparable duration Treasury yield (middle panel, figure 2). Although agency MBS were usually viewed by market participants as effectively backed by the U.S. government, during the autumn of 2008, these spreads increased to above 4 percentage points—more than 200 basis points above their historical

[13] The Federal Reserve Bank of New York publishes an explanation of open market operations each year in its Annual Report. The 2009 Annual Report describes the mechanics associated with the Federal Reserve's purchases of agency MBS and provides information on agency MBS purchases by maturity and by issuer. Such purchases were made across securities with different issuers, maturities, and coupon rates, but were generally concentrated in low coupon, 30-year securities issued by Fannie Mae and Freddie Mac. The agency MBS purchase program also arranged transactions in dollar rolls (i.e., short-term financing vehicles that function similarly to repo, and hence, historically imply similar financing rates in well-functioning markets) in an effort to support MBS financing. For dollar roll purchases, implied financing roll rates were used to indicate dislocations that warranted Desk support.

averages. By the end of the announcement period, mortgage-to-Treasury spread remained quite high.

Even though the initial reviews of the Federal Reserve's MBS purchase program were quite positive, it would take actual MBS purchases to bring about a decline in the mortgage-to-Treasury spread.

MARKET TRANSITION PERIOD—SOME UNCERTAINTY ABOUT GOVERNMENT ACTIONS

The effect of the Federal Reserve MBS purchase program during the announcement period was large because it convinced market participants that the government was committed to a functioning secondary mortgage market. In time, however, mortgage market participants began to question whether or not the Federal Reserve MBS program was big enough to really influence MBS yields over a long horizon. The question these market participants asked was: "If the Federal Reserve purchased $500 billion of MBS, would it accomplish its goals, or would it need to continually "resize" and increase the scale of its MBS purchase program?"

With historically low mortgage rates available, market participants came to expect a large wave of mortgage refinancings would eventually come about. Given this expectation, the MBS purchase program seemed unlikely to be large enough to absorb the expected new issuance of MBS. To put to rest concerns about its MBS purchase program's size, on March 18, 2009, the Federal Reserve increased the total size of the program to $1.25 trillion in MBS purchases. [14]

[14] On Wednesday, March 18, 2009, the Federal Open Market Committee (FOMC) announced that it would provide "greater support to mortgage lending and housing markets" by increasing the size of the Federal Reserve's balance sheet further by purchasing up to an additional $750 billion of agency mortgage-backed securities, bringing its total purchases of these securities to up to $1.25 trillion by the end of the year. See: http://www.federalreserve.gov/newsevents/press/monetary/20090318a.htm. On that date, the MBS-Treasury option-adjusted spreads were almost unchanged and mortgage rates moved slightly lower.

Once the Federal Reserve's MBS purchase program was up and running, it resulted in a gradual elimination of the extreme risk aversion of investors that had built up after the events that occurred in the autumn of 2008. With sustained Federal Reserve MBS purchases and an announcement of an extended and enlarged MBS purchase program, market participants' remaining uncertainty about (1) the success of the Federal Reserve's MBS purchase program, (2) the Federal Reserve's goals with regard to "targeting" the mortgage rate, and (3) the extent and adequacy of the government support for Fannie Mae and Freddie Mac lessened and the crisis premium dissipated.

The disappearance of this crisis premium did not result in a more distinct drop in MBS yields or primary mortgage rates (top panel, figure 2). Instead, as will be discussed below, it was realized by investors in MBS ceasing to use abnormally high mark-ups of MBS yields over swap and Treasury rates. Moreover, the option-adjusted spread on MBS fell to a historically low level during this period (bottom panel, figure 2). [15] Investors and mortgage originators could not maintain the abnormally high mark-ups in a competitive secondary mortgage market environment with the Federal Reserve being a stable and reliable purchaser of current-coupon MBS. In addition, any investors' lingering uncertainty about whether or not the Federal Reserve and the government more generally, was committed to creating an artificially low mortgage rate completely disappeared on May 27, 2009.

NORMAL MARKET PRICING—THE IMPORTANCE OF MAY 27, 2009

Turning back to the top panel of figure 2, it is apparent that mortgage rates increased 38 basis points during the week of May 27, 2009 in tandem with sharply higher yields on

[15] The OAS cited here is the weighted-average of OAS from MBS that bracket the current coupon MBS. The OAS calculation is provided by Bloomberg.

MBS. An increase in longer-term Treasury yields combined with investors' fears associated with higher future longer-term Treasury yields, caused mortgage convexity traders to sell off large quantities of MBS. Higher rates (and expectations of even higher rates) also prompted selling by holders of higher-coupon MBS, as they attempted to lock in the capital gains that had been created by the low MBS interest rate environment.

These mortgage-convexity traders were attempting to balance the duration of their assets (that is, their holdings of MBS) with the duration of their liabilities. As described above, the duration of MBS is particularly difficult to estimate because of the homeowner's prepayment option. When interest rates rise, MBS fall in value because, like all bonds, the value of a fixed-stream of coupon payments is worth less in a higher rate environment. In addition, MBS values fall because homeowners are less likely to prepay their fixed-rate mortgages when rates become higher. This latter effect is referred to as "negative convexity" because, relative to a simple bond, the value of an MBS falls faster when rates rise because the expected maturity of the MBS lengthens.

Many institutions have the objective of holding the duration of their equity within some target range (indeed, often close to zero) because they do not want to take on excessive interest rate risk. For such holders of MBS, when rates rise, or are expected to rise, they often sell their MBS in order to shed duration when it is increasing (so-called extension risk). In addition, holders of duration risk may also try to increase their hedging of MBS convexity (this is referred to as "dynamic hedging") by lengthening the duration of their liabilities. The classic way to hedge an MBS is to sell a fixed-rate interest swap. The value rises for the fixed-rate swap when rates increase, offsetting the loss in value on the MBS.[16]

[16] In a fixed-rate interest swap agreement, the party that pays a fixed rate of interest while receiving a floating rate of interest from the counterpary is a fixed-rate payer. That is, a fixed-rate payer is short the bond market and is long a swap.

Dealers who receive fixed-rate swaps often hedge their risks using the Treasury markets. In response to increased demands for fixed-rate swaps, these dealers shed their longer-term Treasury holdings to lessen the duration of their own portfolios. This shedding of Treasury securities puts further pressure on longer-term Treasury rates to rise. This feedback cycle is called the "mortgage amplification effect" on Treasury rates.[17]

As time passed, the Federal Reserve's efforts to maintain a low mortgage rate were complicated by the increasing lack of predictability in pricing prepayment call options. More uncertain prepayments meant that the Federal Reserve would have to squeeze the MBS option-adjusted spread all the more to get the same amount of MBS spread contraction. Mortgage refinancing speeds were anyone's guess in an environment of credit-constrained households, falling house prices, perceived government-managed mortgage rates and government-mandated refinancing programs, and it was generally believed that even a slight increase in (nominal) mortgage rates would significantly dampen homeowner's incentives to refinance. This line of reasoning made MBS holders all the more likely to sell at the first sign of rising longer-term Treasury yields.

Until May 2009, many market participants seemed to believe that the Federal Reserve was targeting a particular mortgage rate—most believed 4 percent—and would increase its purchase of MBS when interest rates were rising to keep downward pressure on mortgage rates. As a result, these mortgage market participants left their duration positions relatively un-hedged. That is, they were counting on the Federal Reserve to effectively "hedge' against MBS interest rate risks by keeping mortgage rates low.

However, it became clear during May 2009 that the refinancing wave that would allow many homeowners to take advantage of lower mortgage rates was not going to

[17] See Perli, Roberto and Brian Sack (2003) "Does Mortgage Hedging Amplify Movements in Long-term Interest Rates?" *The Journal of Fixed Income*, vol. 13 (3) pp.7–17.

materialize without ever larger Federal Reserve purchases to lower further already historically low mortgage rates. Moreover, as overall Treasury rates began to increase in May, the Federal Reserve did not substantially increase its purchases of MBS (even though it had room to do so within the cap for its MBS purchase program).

Once the market understood that the Federal Reserve was not targeting a mortgage rate, but was just mechanically purchasing a relatively fixed amount of MBS issuance each day in order to accumulate its announced purchase amount, many private investors exited the MBS market because they did not believe their compensation would cover the costs of hedging their potential interest rate risks. This market dynamic created a rapid sell off of agency MBS on May 27, 2009.

As a result of the exit of many private MBS investors and as a result of the generally low level of mortgage refinancings and originations, the Federal Reserve became an even more important purchaser of new GSE MBS issuance after May 27 2009. The substantial sell off of MBS by mortgage-convexity traders during the week of May 27 was portrayed by some observers as a test of the Federal Reserve's resolve in maintaining low MBS yields (or, alternatively, in holding the line on longer-term Treasury yields) in its effort to assure mortgage rates would stay low and the housing market would recover more quickly. Ironically, however, as private participants exited the market, the result was that the Federal Reserve's purchases could place even more downward pressure on MBS OAS: With the resulting MBS spreads, it was difficult for some private participants to bear the cost associated with hedging their positions when holding current-coupon MBS.

With the elimination of the uncertainty concerning the Federal Reserve's objective, the market returned to more normal market pricing relationships.

4. USING REGRESSION ANALYSIS TO DETERMINE THE EFFECT OF THE FEDERAL RESERVE'S MBS PURCHASE PROGRAM ON MORTGAGE RATES

The spread between the yield on MBS and the yield on Treasury securities is a common measure of investors' risk compensation for holding MBS. A longer history of the spread between MBS yields and (duration-matched) Treasury rates is shown in the top panel of figure 3. From this chart, one can see that the movements of the MBS-Treasury spread over the past ten years can be broken into five distinct intervals: (1) the "pre-subprime" or "normal" mortgage era (from July 2000 through March 2004); (2) the "subprime dominance" era (from April 2004 through July 2007); (3) the financial crisis (from August 2007 until the Federal Reserve's intervention on November 25, 2008); (4) the period of Federal Reserve intervention in the MBS market (November 25, 2008 to March 31, 2010), and (5) the post-Fed intervention period (April 1, 2010 through November 2010). [18] While there is some ambiguity about the beginning- and end-points of each of these periods, it is apparent that the MBS-Treasury spread is somewhat level during the "normal" era, persistently declines during the "subprime dominance" era, rises sharply during the financial crisis, and then declines to a level consistent with the "normal" era after the Federal Reserve's intervention.

As shown in the middle panel, the option-adjusted spread (OAS) on MBS—another common measure of MBS investors' risk—follows a similar pattern. However, while the secular trends are very similar, it is apparent from a comparison of the top and middle panels

[18] A weighted average of MBS yields that bracket current coupon MBS is used. The Treasury yield is chosen from an interpolated yield curve using the average duration of the bracketed current coupon MBS. Bloomberg information on durations and MBS yields are used in these calculations.

that the correlation of the OAS with the MBS-Treasury spread is neither constant, nor straightforward.[19]

The MBS-yield-to-Treasury-yield spread for similar duration financial instruments is one of the key benchmarks for the cost of mortgage credit. The other key benchmark is the spread between the MBS-yield and a relatively long maturity swap rate (figure 3, bottom panel). In both cases, the benchmark spread approximates the return to holding MBS and the difference depends on the method of financing that is used by the holder of MBS. Similar to the MBS yield-Treasury spreads (top panel, figure 3), there appears to be five distinct periods for the MBS yield-long-maturity swap spread (bottom panel, figure 3).

We employ time series regressions to examine the determinants of mortgage rates and the possible effect of the Federal Reserve purchase program on mortgage rates. To do so, we estimate a two-stage "mark-up" model of mortgage rates, which reflects the linkages between the primary and secondary mortgage markets described above. In the first stage, we consider the determinants of yields on MBS. And in the second stage, we model how yields on MBS influence mortgage rates.

STAGE 1: DETERMINANTS OF MBS YIELDS

In the first stage, MBS yields are described as a (linear) function of four variables: (1) a long-term swap rate; (2) a short-term swap-to-Treasury spread; (3) a proxy for prepayment risks; and (4) a proxy for rollover risks. As shown in the top panel of figure 4, MBS yields plummeted with the announcement of the Federal Reserve's MBS purchase program on November 25, 2008. Prior to that announcement, MBS yields had stayed

[19] The correlation between the two series is just 0.46.

remarkably constant. Thus, the risk premiums in the MBS market reflected mainly movements in underlying benchmark rates (either Treasury, or swap rates).

Because these risk premiums for MBS tumbled after the Federal Reserve's intervention—MBS yields fell more than either Treasury, or swap rates—this decline in spreads provides evidence that suggests that the market perceived that a substantial risk had been removed from the MBS. Of course, the risk that was dominant and specific to the MBS market at this time was the credibility of Fannie Mae and Freddie Mac's government backing.

As discussed above, private investors in MBS often purchase an interest rate swap, for which they pay the fixed-portion of the swap and receive the short-term variable payment; almost always a payment based on the three-month Libor rate. This interest rate swap removes the interest rate risk associated with holding the MBS if the holder is funded by very short-term (three-month) liabilities. We average across the five-year and ten-year swap rates to approximate these average costs of hedging MBS, which typically have durations that run between three and six years. The ten year history of long-term swap spreads is provided in the middle left panel of figure 4. Strikingly, during the period of the Federal Reserve's MBS purchase program, these swap rates fell to historically low levels.

Using a long-term swap to hedge mortgage interest rate risk would still leave the holder of the MBS with a significant maturity mismatch and some basis risk if its underlying funding structure is not similar to three-month Libor. Among the major holders of MBS described above, it is difficult to know who the "marginal" holder of MBS is at any point in time. For our stage-one description of MBS yields, we will assume that the marginal portfolio purchaser of MBS is a "bank," which typically would have a duration of its liabilities that would be fairly short (e.g., one or two years). Our "bank" is modeled as using

a swap to convert its three-month Libor payment for an average yield on one-year and two-year Treasury securities to help match its duration. Because the "bank" would still likely continue to have basis risk (since its liability structure would probably be more sensitive to Treasury rates than to the average swap rates), we also include the spread between the short-term swap rate and the Treasury rate in the regression as a proxy for the cost of this basis risk. As shown in the middle right panel of figure 4, basis risk increased significantly during the crisis, but fell to relatively low levels after the Federal Reserve's intervention in the MBS market.

Recall that MBS holders are compensated in their yields for offering homeowners a prepayment option. Usually, an estimate of the cost of the prepayment option is a model-based estimate of the fair value of selling the option to the homeowner. It reflects the cost to the investor of either being forced into a low-yielding asset during a period of low interest rates, or the risk of carrying un-hedged interest rate risk, if interest rates rise and the mortgage is outstanding longer than expected (so-called extension risk). Beyond these risks, an investor might also be left with swap obligations that cannot be easily met from the cash flows of his (or her) underlying assets.

The valuation of the prepayment options of homeowners is extremely difficult and complex even in normal circumstances. Since the financial crisis, prepayment models have been considerably more unreliable.[20] Given that even the best pre-payment option models that money can buy could not reliably gauge prepayment risk over our estimation periods, we use a simple measure—the difference of the mortgage rate averaged over the past three years and the current mortgage rate. This variable measures the risk that the stream of MBS

[20] Despite a lower OAS spread, the compensation for prepayment risk increased during the financial crisis period. This increased compensation mainly reflected the uncertainty associated with estimating mortgage prepayments. Indeed, since MBS duration has increased and convexity has decreased over the financial crisis period, the costs of hedging a "given level" of pre-determined prepayment risk actually fell during the period.

payments is terminated either sooner (because of a relatively low mortgage rate environment) or later (because of a relatively high mortgage rate environment) than was expected. Like all other measures of prepayment risk, this measure indicates that such risks were high during the period of the Federal Reserve's invention (bottom left panel, figure 4), even though actual refinancing rate of mortgages was very low compared to the past. In fact, the level of actual prepayments was low relative to the historical level associated with low mortgage rates because many households had home values that had fallen near (or even below) their outstanding mortgage value (i.e., their mortgages were "under water"); because the credit quality of many households had deteriorated; because many household balance sheets had deteriorated; and/or because of higher costs that were associated with refinancing a mortgage during the past several years.

Lastly, we account for the "rollover risk" that is associated with the shorter-term swap in our MBS yield specification. We use the volatility (measured by the 90 percent confidence interval) of the forward swap rates implied by swaptions between two and ten years to proxy for rollover risk during the life of the mortgage that results from financial market disruptions, credit downgrades, and other unanticipated events.[21] As shown in the lower right panel, this measure of rollover risk follows the expected pattern—falling sharply during the era of subprime dominance, rising sharply during the crisis, and then declining to something near a "normal" level after the Federal Reserve's intervention into the MBS market.

The intercept included in our MBS yield specification is interpreted as the average option-adjusted spread (OAS) on MBS over the period of estimation for a completely hedged

[21] A swaption is an option to enter into an interest rate swap at a future date.

position.[22] In this case, the OAS is the yield above a risk-free rate that was received from holding MBS (after accounting for the costs associated with hedging the prepayment and funding risks).

STAGE 1: A REGRESSION ANALYSIS OF MBS YIELDS

Normal Pricing Era. Our results for the first-stage regression that describe MBS yields during the "normal" era (July 2000–March 2004, inclusive) are provided in the top panel of table 1.[23] As expected, swap rates are highly correlated with MBS yields with an estimated coefficient nearly equal to one. This high correlation is not surprising because almost all market participants make reference to longer-term swap rates when pricing MBS.

The coefficient on our measure of basis risk could have been either positive or negative since it depends on (1) the liability structure of the institutions financing the mortgages, and (2) the supply and demand conditions in both the swap and Treasury markets, which are not possible to measure with available data. Using data from the "normal" period, the regression coefficient for our measure of basis risk is slightly negative, suggesting that the marginal holder of MBS during the "normal" period may need to make only a small adjustment for basis risk. As for the intercept, it is negative and significant, which is inconsistent with our interpretation that the intercept as an "option-adjusted" yield (and which may reflect the imperfect nature of our proxies for risks).

As for prepayment risks and rollover risks (that were proxied using the uncertainties involved with extending two-year swaps into the future), both risks added to the costs of

[22] The intercept may also provide a "level adjustment" that accounts for the imperfect nature of our data and our assumption that a "bank" is the marginal holder of the MBS, rather than a different type of investor.

[23] The variables used in the regressions that follow are I(1) variables. Each of the regressions discussed are cointegrated regressions with residuals that are I(0).

holding MBS during the "normal" period (about 25 basis points for prepayment risks and about 83 basis points for liability swap extension risk, on average).

Subprime Dominance Pricing Era. In the bottom panel of table 1, the same regression specification is used to describe the "subprime dominance" period (April 2004–July 2007, inclusive). As was the case during the "normal" era, the long-swap rate is the key determinant of the MBS yield during the "subprime dominance" era, with an estimated coefficient value that is significant and close to equaling one in value.

Unlike during the "normal" era, during the "subprime dominance" era, the estimated coefficient on the prepayment risk proxy is close to zero and statistically insignificant. That said, bond volatility—our proxy for the rollover risks associated with hedging—is again positive and significant during the "subprime dominance" era. This risk accounted for about 55 basis points of the MBS yield on average. It is, perhaps, a bit surprising, but the intercept is estimated to have been positive and significant during the "subprime dominance" era. This positive and significant intercept coefficient is consistent with the view that a fully-hedged position during the "subprime dominance" era, as measured by our very imperfect proxies, would still have required some "option-adjusted" risk compensation.

Subsequent Eras. To consider the effects of the financial crisis and of the Federal Reserve's intervention on MBS yields, we examine the *out-of-sample* fits of the regressions estimated during the "normal" and "subprime dominance" eras. As shown in the top panel of figure 5, the out-of-sample fit for the "normal" era pricing regression is quite tight until the onset of the financial crisis. During the crisis, the actual MBS yield (shown using a solid red line) becomes strikingly higher than the predicted MBS yield using the "normal" era pricing regression (shown using a dashed blue line) until May 27, 2009 (figure 5, middle panel). After May 27, however, the fit for the "normal period" regression is once again fairly tight

and the observed MBS yield is only about 16 basis points lower (on average) than the predicted MBS yield.

Using the MBS pricing model that was estimated using data from the "subprime dominance" era, the out-of-sample fit during the "normal" period is very tight (top panel, figure 6). As was the case with the "normal" era regression, the out-of-sample fit for the regression estimated with time-series data from the "subprime dominance" era deteriorates markedly during the financial crisis. This similar pattern is a little surprising given the differences between the regression results for the two periods: That is, prepayment risks seemed to have been ignored by investors during the "subprime dominance" era since proxies for such risks were not significant in the regression model estimated with data from that time period. Nevertheless, the end result is the same: After May 27, 2009, MBS yields largely returned to reflect fundamentals since the actual MBS was only 8 basis points lower than the predicted yield on average.

Figure 7 compares the two MBS yield predictions (top panel) and the deviations between the actual and predicted MBS yields (bottom panel) derived from employing the MBS yield regressions that were estimated using time-series data from the "normal" and "subprime dominance" eras. From late 2005 until May 2009, the MBS yield predicted value derived using data from the "subprime dominance" era (shown using a solid blue line) was persistently higher than the MBS yield predicted value derived using data from the "normal" era (shown using a dashed red line). This finding is consistent with MBS yields being "too low" during the "subprime dominance" era.

The out-of-sample deviations from predicted values derived from the regressions estimated for MBS yields suggest that risk-premiums were dissipated after May 27, 2009 (bottom panel). This transition, however, was not immediate. During the announcement

period, the out-of-sample deviations averaged 74 basis points. These deviations only fell towards the end of the announcement period, once purchases were eminent and certain (that is, only after a press release confirmed that purchases would soon begin on December 30, 2008). As purchases began and the market developed an understanding of the Federal Reserve's objectives, MBS pricing deviations gradually declined to be close to zero.

It is our view that the Federal Reserve's persistent and consistent *purchases* of MBS removed the undue mark-ups (i.e., risk premiums) from the MBS market, as investors realized that the Federal Reserve was a reliable purchaser, but that it was not targeting a specific low mortgage rate (e.g., four percent). The tumble in MBS yields at the time of the Federal Reserve's announcement of its MBS purchase program reflected the overall market relief that the government was taking actions to stabilize mortgage markets and to harden the government's backing of GSE MBS. That said, actual GSE MBS purchases were needed to remove excessive risk premiums from the secondary mortgage market.

STAGE 2: DETERMINANTS OF MORTGAGE RATES

As we discussed above, mortgage rates are determined by the funding cost for the marginal mortgage. Generally, the banking system's ability to bear credit risk relative to the ability of the GSEs to bear credit risk is the key determinant of this funding cost for the marginal mortgage because the bank, who originates the mortgage, decides whether to hold a mortgage directly or pay the GSE guarantee fee and effectively hold the mortgage as a GSE MBS (with no credit risk to the bank). During the financial crisis, however, the GSEs securitized almost all conforming mortgages that were originated. In this environment, the mortgage rate became a fairly straightforward "mark-up" over the MBS yield for all market participants.

As shown in the top panel of figure 8, the spread between the observed mortgage rate and the Treasury yield declined substantially during the announcement and market transition periods of the Federal Reserve's purchase program. After May 27, 2009 this mortgage rate spread once again aligned with its value (on average) observed during the "normal" era.

The level of the mortgage rate (figure 8, middle panel) quickly dropped about 125 basis points at the time of the Federal Reserve's MBS purchase program announcement. Indeed, the mortgage rate remained near the 5 percent level throughout the period of the Federal Reserve's intervention (5.06 percent on average).

The mortgage rate is modeled as a mark-up over the MBS yield. This mark-up is proxied by a crude measure of the costs associated with origination, servicing and managing the credits risk of mortgages—a daily index of house prices (shown in the bottom panel of figure 8). We used this measure because house prices incorporate a forward-looking component that reflects expectations of interest rates, as well as determinants of housing market conditions such as unemployment, delinquencies, and default. These determinants underlie the credit risks and the costs of servicing mortgages, which comprise the mark-up over MBS yields. We also incorporated lags into the regression specification for mortgage rates in order to reflect the timing of when information becomes available to investors. For example, the house price index was lagged ten weeks (i.e., the value of the index ten weeks ago is assumed to be the most current value that would be known today).

In our mortgage rate regressions, the MBS yields are the key determinants of mortgage rates and this (lagged) variable is statistically different from zero in both the "normal" era and the "subprime dominance" era (table 2, top and bottom panels, respectively). The home price index is also an important determinant of mortgage rates. As home prices rise, the credit and servicing costs of mortgages fall. Hence, it is not surprising

that the coefficient for the home price index was negative (and statistically significant) regardless of whether time-series data were employed from either the "normal" or the "subprime dominance" eras. The intercept in our mortgage rate regressions, which may reflect origination risks, economies of scale of mortgage origination, or the market concentration of mortgage originators, was significantly higher in the "normal" era (top panel) than in the "subprime dominance" era (bottom panel). One possibility is that the hyper-competition for mortgage originations during the "subprime dominance" period lead to narrower margins.

In figure 9, the mortgage rate regression for the "normal era" is used to compute out-of-sample predictions for the mortgage rate. These out-of-sample predictions suggest that the mortgage rate was "too high" during the latter part of the subprime dominance era and during the crisis period. In contrast, after the Federal Reserve's intervention, the out-of-sample predictions are higher than the observed mortgage rate (middle panel, figure 9). The low level of observed mortgage rates after the Federal Reserve's intervention reflects the generally lower MBS yield that is predicted by the MBS yield regression estimated using time-series data from the "normal" era. During the period of the Federal Reserve's intervention, the actual mortgage rate, by this estimation, became persistently about 20 to 30 basis points lower than predicted (bottom panel, figure 9).

In contrast, a comparison of actual mortgage rates with predicted mortgage rates derived using data from the "subprime dominance" era, suggests a relatively close fit during the crisis period (figure 10). Moreover, this close alignment of actual and predicted mortgage rates continues during the period of Federal Reserve intervention (figure 11, bottom panel). This finding suggests that mortgage pricing after the Federal Reserve's intervention was similar to the mortgage pricing during the "subprime dominance" era.

Moreover, when this close fit is contrasted with the divergence between actual and estimated mortgage rates derived using the regression that was estimated using data from the "normal" period era, the evidence suggests that the Federal Reserve, by providing a persistent and consistent demand for MBS, mimicked the intense demand for government-backed MBS during the era of "subprime dominance" and thereby lowered risk premiums in the mortgage market.

THE INFLUENCE OF THE FEDERAL RESERVE'S MBS PURCHASE PROGRAM ON SWAP RATES

Observed mortgage rates were at historically low levels throughout the course of the Federal Reserve's MBS purchase program. According to our estimates, MBS yields were low because swap rates were also low. As shown in the top panel of figure 11, the long swap rate fell sharply after the Federal Reserve's intervention. The long swap rate is closely tied to similar maturity Treasury yields (bottom panel, figure 12).

The Federal Reserve essentially tried to drive longer-term interest rates lower by withdrawing supply from the fixed-rate financial asset markets and forcing investors to overcome their risk aversion and rebalance their portfolios. One might argue that $1.25 trillion in MBS would be too small to have this affect in a normal environment because there are over $23 trillion of fixed-rate, high-quality, dollar-denominated financial assets. However, the financial crisis called into question the validity of credit ratings for fixed-rated assets and increased the demand for "full faith and credit" government-backed securities. As a result, the $1.25 trillion dollar withdrawal of MBS was a much larger fraction of the relevant market as far as risk-averse investors were concerned. Thus, the "portfolio balance effect" might be greater during period of financial crisis because of investors' views of acceptable substitutions for government-backed assets are much more limited.

As shown in table 3, simple regressions of the long swap rate on the long Treasury yield highlight the tight connection between these two rates. We model the average of five and ten-year swaps rates as a linear function of a Treasury rate of the same maturity. We run such regression specifications using data for both the "normal" and "subprime dominance" eras.

Our indicative regressions suggest that during the financial crisis, swap rates increased to be above their normal relationship with Treasury rates (figures 13 and 14). The Federal Reserve's intervention closed this divergence between the swap rate and the Treasury yield. After May 27, 2009, the predicted long swap rate became persistently higher than the actual long swap rate. This finding suggests that the persistent purchases of MBS by the Federal Reserve may have lowered overall interest rates by a few basis points.

How much of the lower mortgage rate environment can be attributed to the MBS purchase program? The program put downward pressure on all rates as investors had to rotate from MBS into other financial assets in order to generate adequate investment returns (particularly since the Federal Reserve's purchases substantially exceeded the flow of net new MBS issuance during most of the intervention period). Indeed, many large MBS investors, such as foreign investors and money market managers, switched into Treasury bonds because they perceived there was little return (as measured by OAS) to holding GSE MBS.

SUMMARIZING THE EFFECTS OF THE FEDERAL RESERVE'S PURCHASE PROGRAM

We use a simple decomposition of the mortgage rate to summarize the effects of the Federal Reserve's mortgage purchase program. The changes in the mortgage rate can be broken into the changes in (1) the abnormal mortgage pricing (i.e., the change in the

difference between the expected and actual mortgage rate), (2) the abnormal MBS pricing (i.e., the change in the difference between the expected and actual MBS yield), (3) the predicted MBS yields, and (4) the primary mortgage market costs. In other words, if:

$$Mortgage\ Rate = \ Risk\ premium + \alpha * MBS\ Yield + \beta * House\ Price\ Index$$

then

$$\Delta Mortgage\ Rate = \Delta Abnormal\ Mortgage\ Pricing + \alpha * \Delta Abnormal\ MBS\ Pricing + \alpha * \Delta Predicted\ MBS\ Level + \beta * \Delta Change\ in\ Primary\ Mortgage\ Market\ Costs.$$

We interpret the changes in abnormal market pricing (both in the mortgage and MBS markets) as measures of market functioning. In contrast, the changes in the predicted MBS yield is interpreted as evidence of a portfolio rebalancing effect, particularly when it is driven by changes in the long swap rate. Our reasoning is that if market functioning is "held constant," then changes in predicted MBS yields are driven by the relative attractiveness of being the fixed-rate receiver of a swap. If there is a lot of duration in the market, then there will be greater demand to swap out of fixed-rate positions and in return receive variable payments. The interest rate on the swap will rise (that is, to receive the variable payments, the purchaser of the swap will need to pay more to the seller). In contrast, if aggregate duration is falling (perhaps because the Federal Reserve is removing duration from the market), then swap demand falls and the yield on fixed-rate swaps declines.

As argued and estimated above, the key component of expected MBS yields is the swap rate. If Federal Reserve purchases are expected to remove duration from the markets,

then holders of fixed-rate assets will rebalance their positions and use fewer swaps. If market participants expect duration to be withdrawn from the market, then swap rates will fall and predicted MBS yields will fall.

We provide in table 4 the changes in the data and deviations from the predicted values. In table 5, we make the calculations for the changes in market functioning and for the effects of portfolio rebalancing in each period.[24] As shown in row 1, mortgage rates fell 97 basis points during the announcement period. As shown in columns 2 and 3, this decline was partially driven by significant declines in measures of abnormal MBS pricing during this period. In addition, as shown in column 4, portfolio rebalancing effects were also very strong, with the long swap rate falling and substantially driving down predicted MBS yields. Therefore, our estimates suggest that during the announcement period, the Federal Reserve's actions significantly reduced mortgage rates by significantly reducing overall interest rates, and improving market functioning.[25]

After the announcement period, the effects of the Federal Reserve's MBS purchase program become more difficult to determine. During the market transition period (row 2), there was a smaller but still noticeable decline in mortgage rates. However, this smaller decline hides two offsetting effects. Federal Reserve actions seemed to continue to improve market functioning (columns 2 and 3). But continued market turmoil and, as described above, possible poor Federal Reserve communication about the objective of the MBS purchase program, led to higher swap rates (column 6), which pushed up predicted MBS yields.

[24] The "changes over eras" shown in tables 4 and 5 represent the changes of 3 and 7 period moving averages, for weekly and daily data respectively. This is done to mitigate the effect of volatility.

[25] Over our entire sample, the mean weekly change in mortgage rates is zero and the standard deviation is 10 basis points, the four-week mean change is -3 basis points and the standard deviation is 22 basis points, and the 12-week mean change is -9 basis points and the standard deviation is 37 basis points.

We have highlighted the importance of May 27, 2009 as a date that the markets became clear about the Federal Reserve's goals regarding its MBS purchase program. During the normal pricing period (row 3), there is little change in mortgage rates. Indeed, there is little change in rates overall. Market functioning seems to have stabilized.

With the end of the Federal Reserve MBS purchase program, mortgage rates fell dramatically. Ironically, this may be the period where the Federal Reserve stock of MBS holdings had its greatest effect on mortgage rates. In early summer 2010, market participants had expected significant new net issuance of MBS because of their perception that housing purchases were picking up and that mortgage refinancings would be stronger (causing a shift in the stock of MBS holdings from the Federal Reserve to the private market). Moreover, demand was viewed as likely to lessen as the economy strengthened and alternative uses for funds other than for holding Treasuries and MBS became more attractive. Instead, the housing market and mortgage refinancings continued to be at disappointing levels and the demand for MBS by financial institutions to "park funds" only intensified. As a result, the Federal Reserve's holdings of MBS as a proportion of outstanding MBS has held relatively constant. Our measures of market functioning and portfolio rebalancing effects suggest that markets were in good shape (columns 2 and 3) and the portfolio rebalancing effects were very strong (column 6). The result was significant downward pressure on mortgage rates (these declines were also concurrent with the flights to quality because of problems with Europe sovereign debt). Thus, a lot of "quantitative easing" may have already occurred "naturally" in the MBS market.

5. CONCLUSION

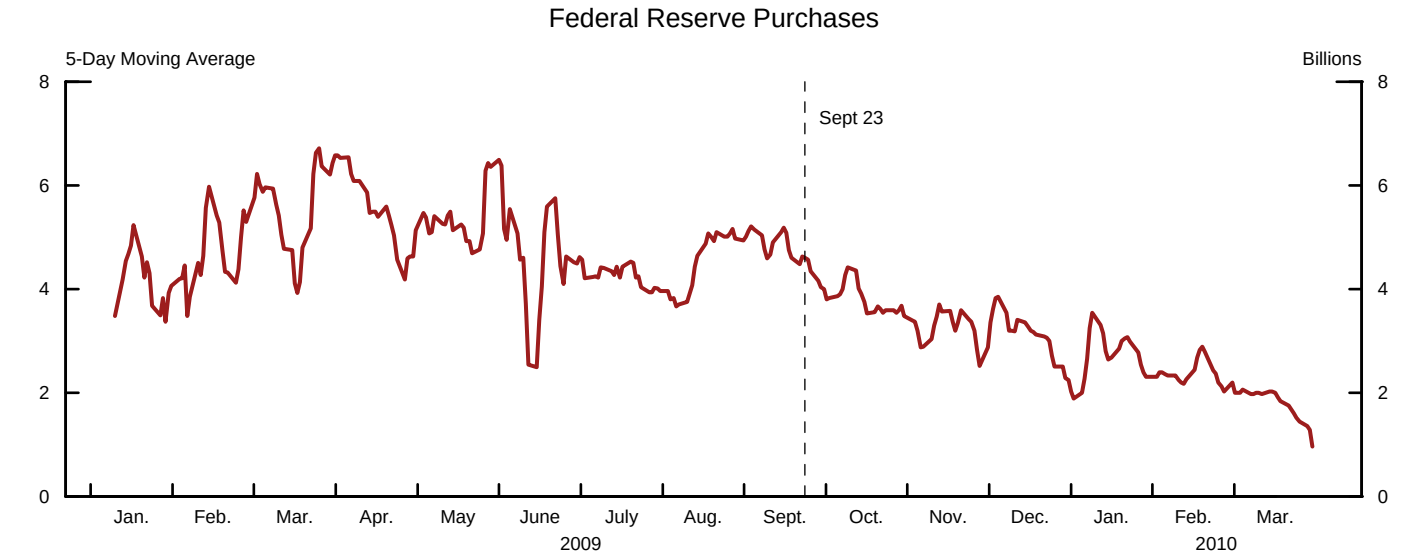
The announcement of the Federal Reserve's MBS purchase program clearly and substantially improved market functioning. Moreover, these effects can be classified into three groups: (1) market functioning, (2) clearer government backing, and (3) anticipation of portfolio rebalancing effects. The causes of the interest rate declines associated with the announcement of the MBS purchase program is important if one is considering whether or not the Federal Reserve's experience with the announcement of the MBS purchase program is repeatable. If the sharp drop in interest rates resulted strictly from improved market functioning, then the experience is unlikely to repeat itself outside of a financial crisis. However, if the drop in rates was the result of a market surprise and subsequent anticipation of future Federal Reserve purchases, then future MBS purchases might also lead to lower MBS yields and mortgage rates.

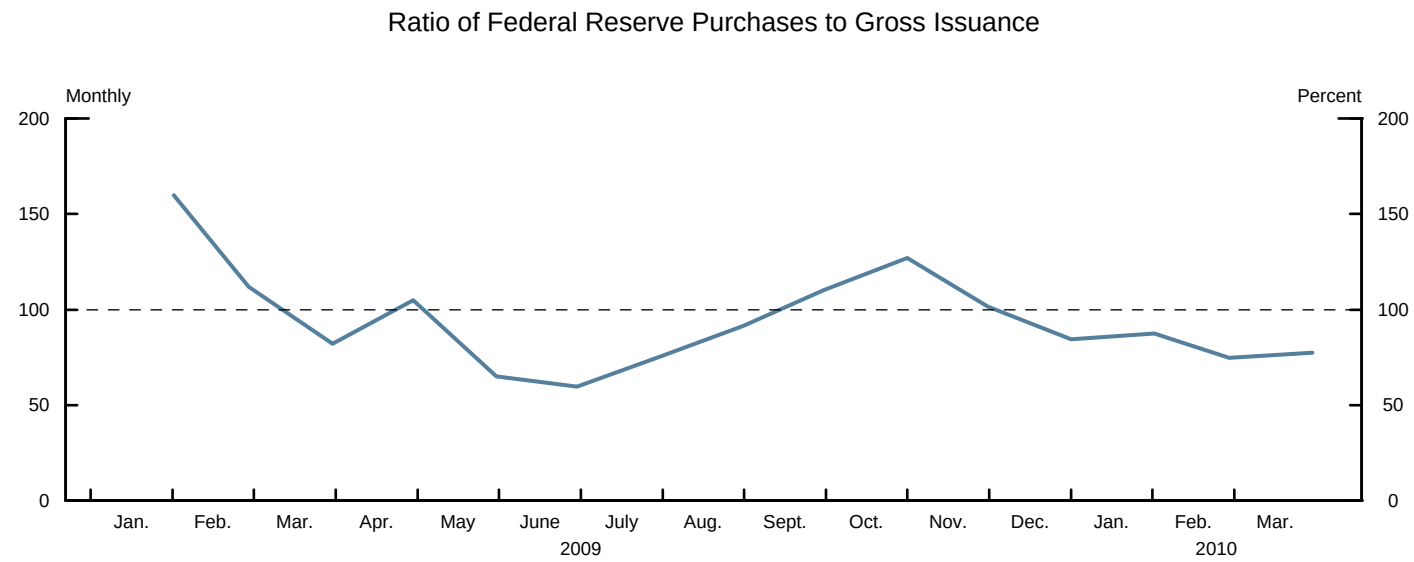
Here, we develop an empirical technique that can be used to distinguish the three separate effects of the Federal Reserve's MBS program on mortgage rates. Our results suggest that around half of the declines were associated with improved market functioning and about half with declines in risk premiums that were associated with changes in the compensation for holding fixed-rate financial assets over a long period. Our results have to be taken with a large grain of salt given the uncertainties in modeling. We also find that some of the effects of quantitative easing were lost during the first quarter of 2009, perhaps because of market confusion about the objectives of the program. Many participants thought that the Federal Reserve might be targeting a particular mortgage rate and this belief lead to a "dumping" of higher-coupon MBS that offset some of the benefits of the program. Lastly, we find that if portfolio rebalancing had a substantial effect, it may have had its greatest

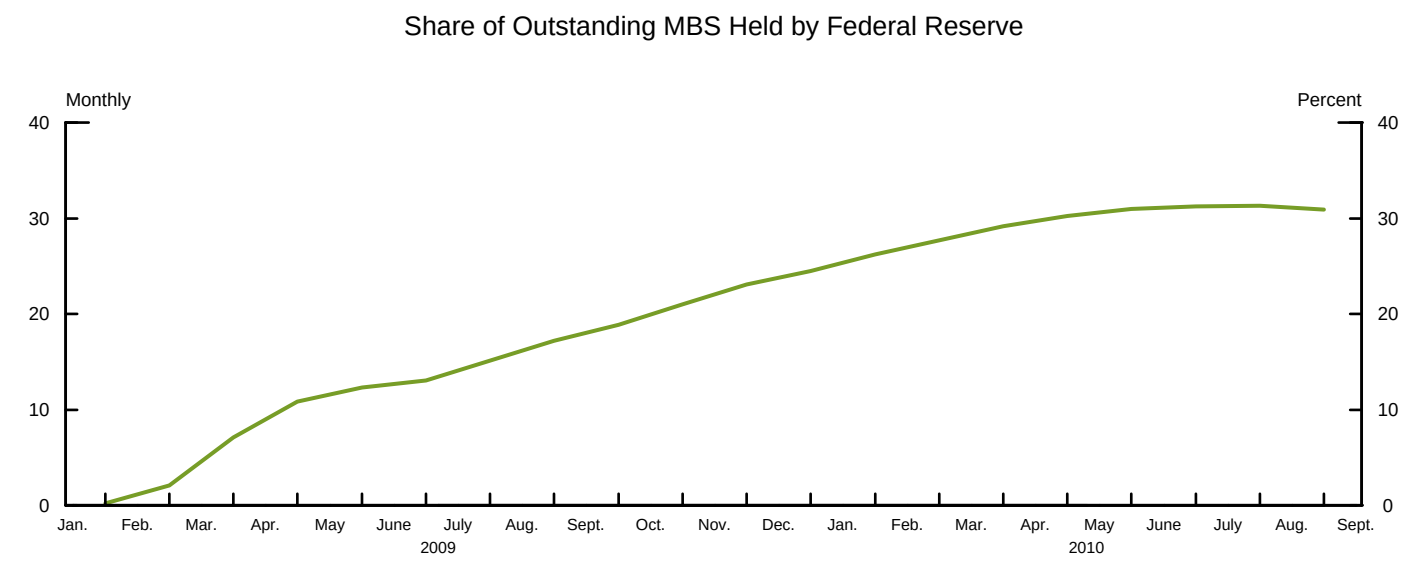
importance only after the Federal Reserve's purchases ended, but while the Federal Reserve held a substantial portion of the stock of outstanding MBS.

Figure 1

Federal Reserve Intervention in the Agency MBS Market



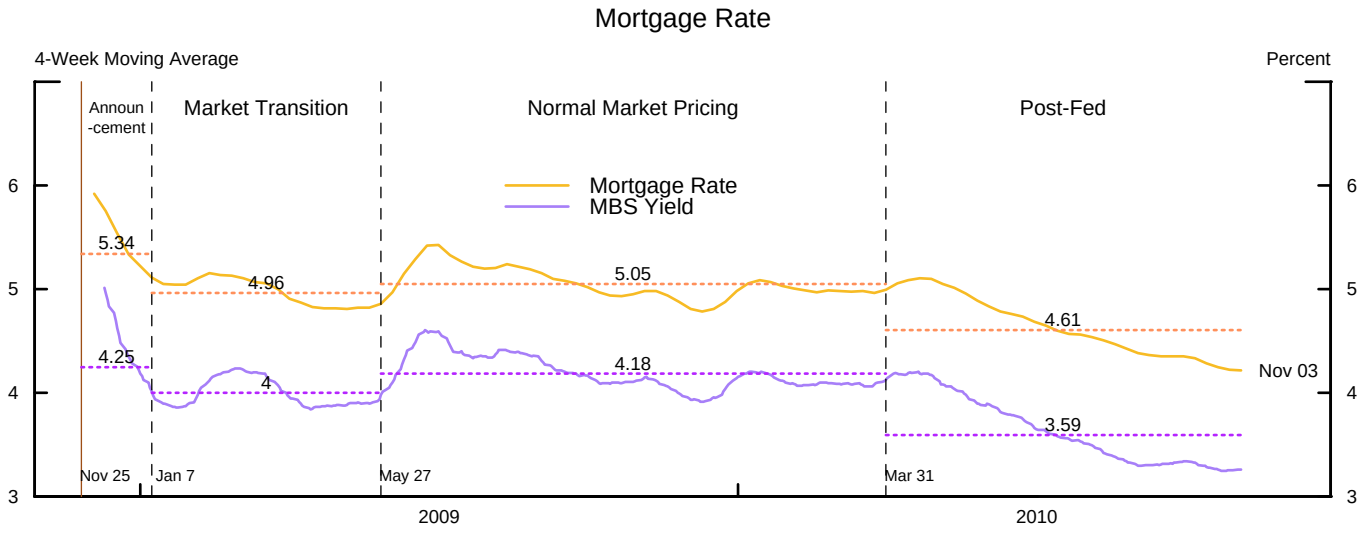


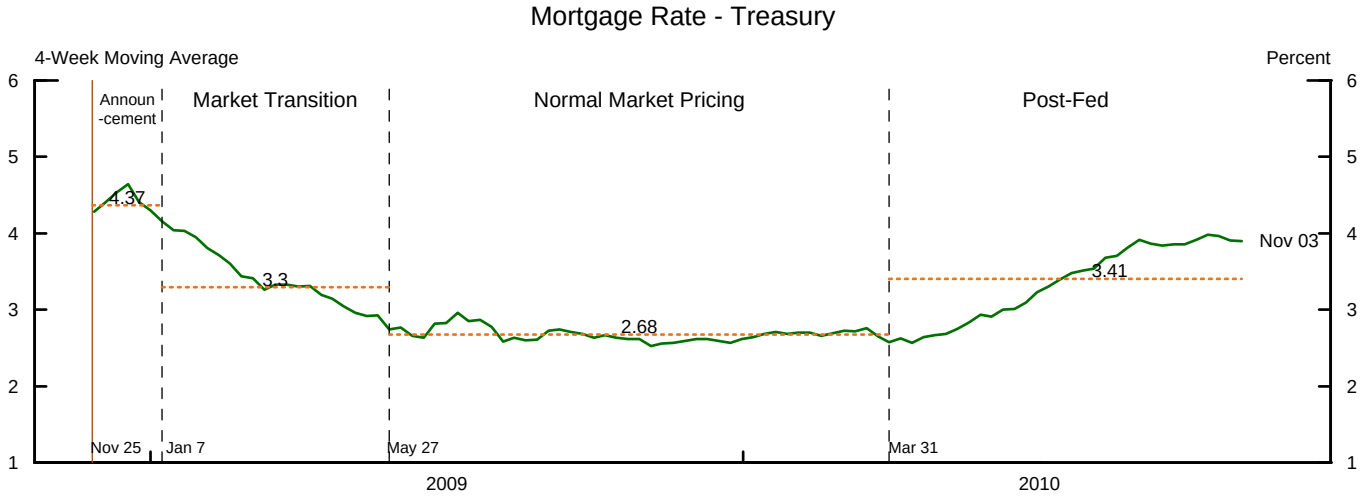


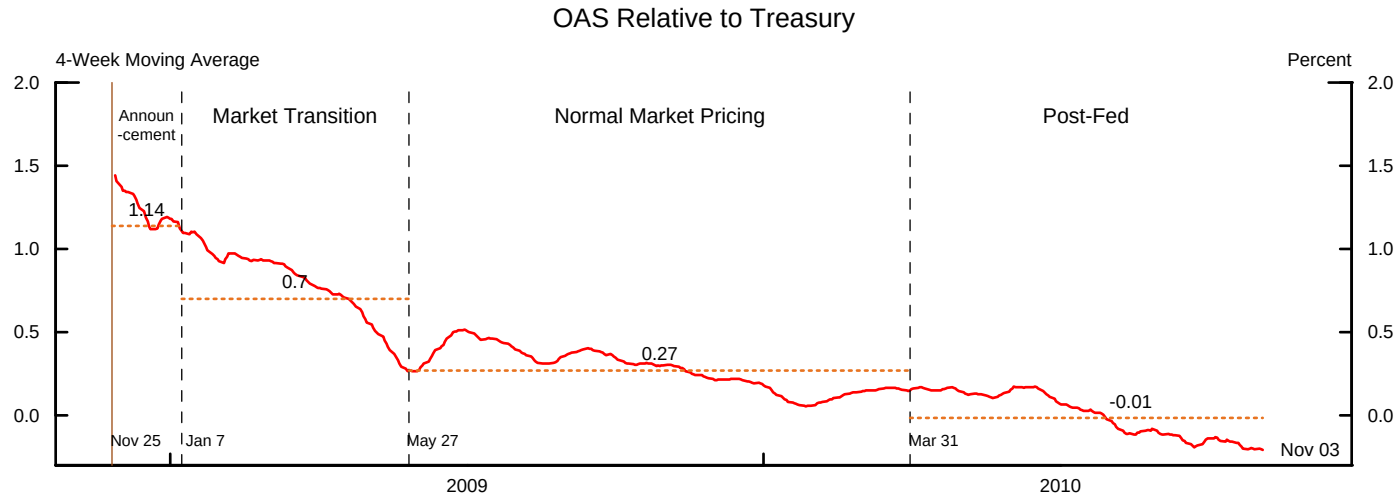
Source: eMBS.com, FRBNY

Figure 2

Mortgage Rates and Mortgage Risk Premiums





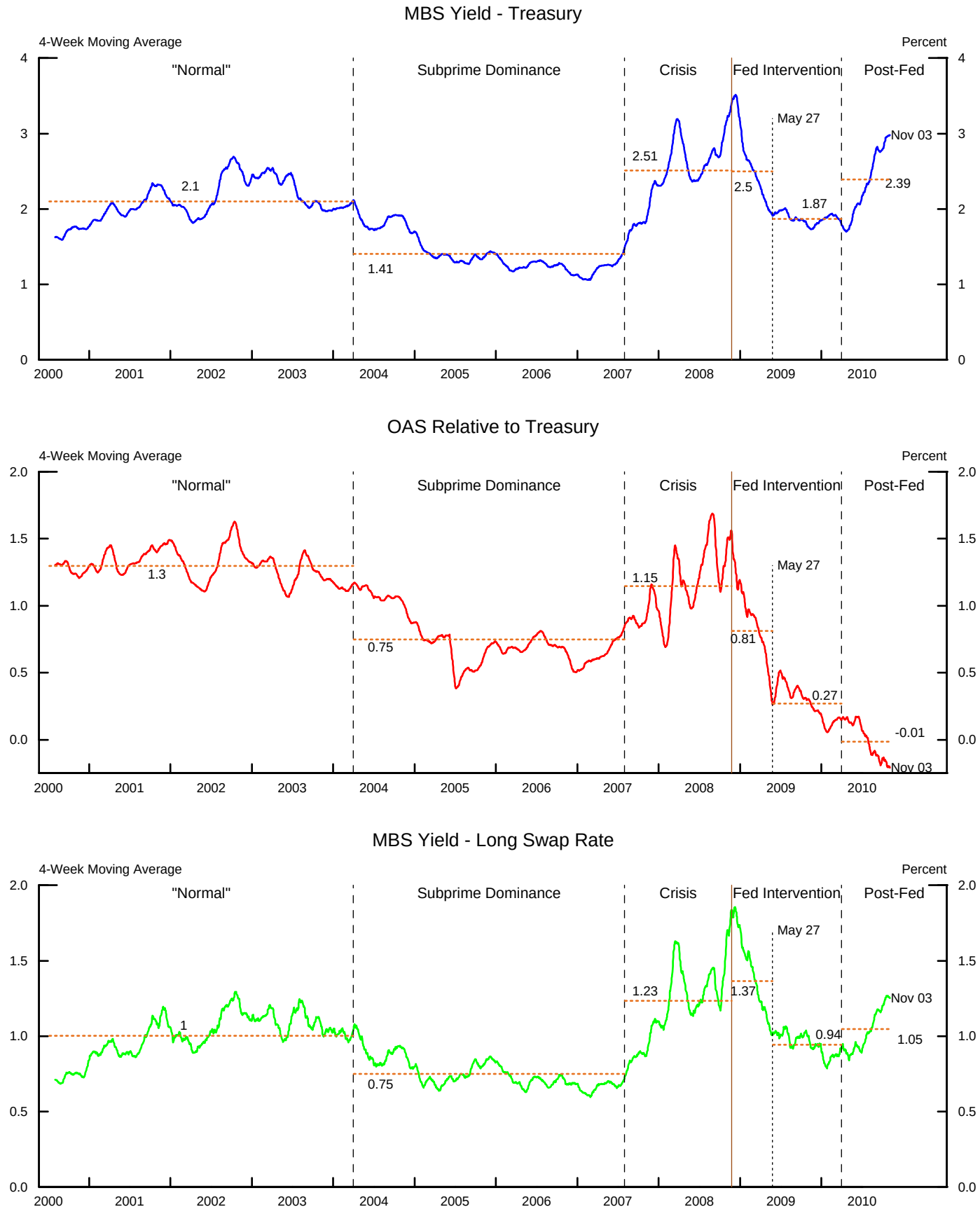


Source: Freddie Mac, Bloomberg

Note: Means in each era indicated by dashed lines

Figure 3

Risk Premiums in the Secondary Mortgage Market

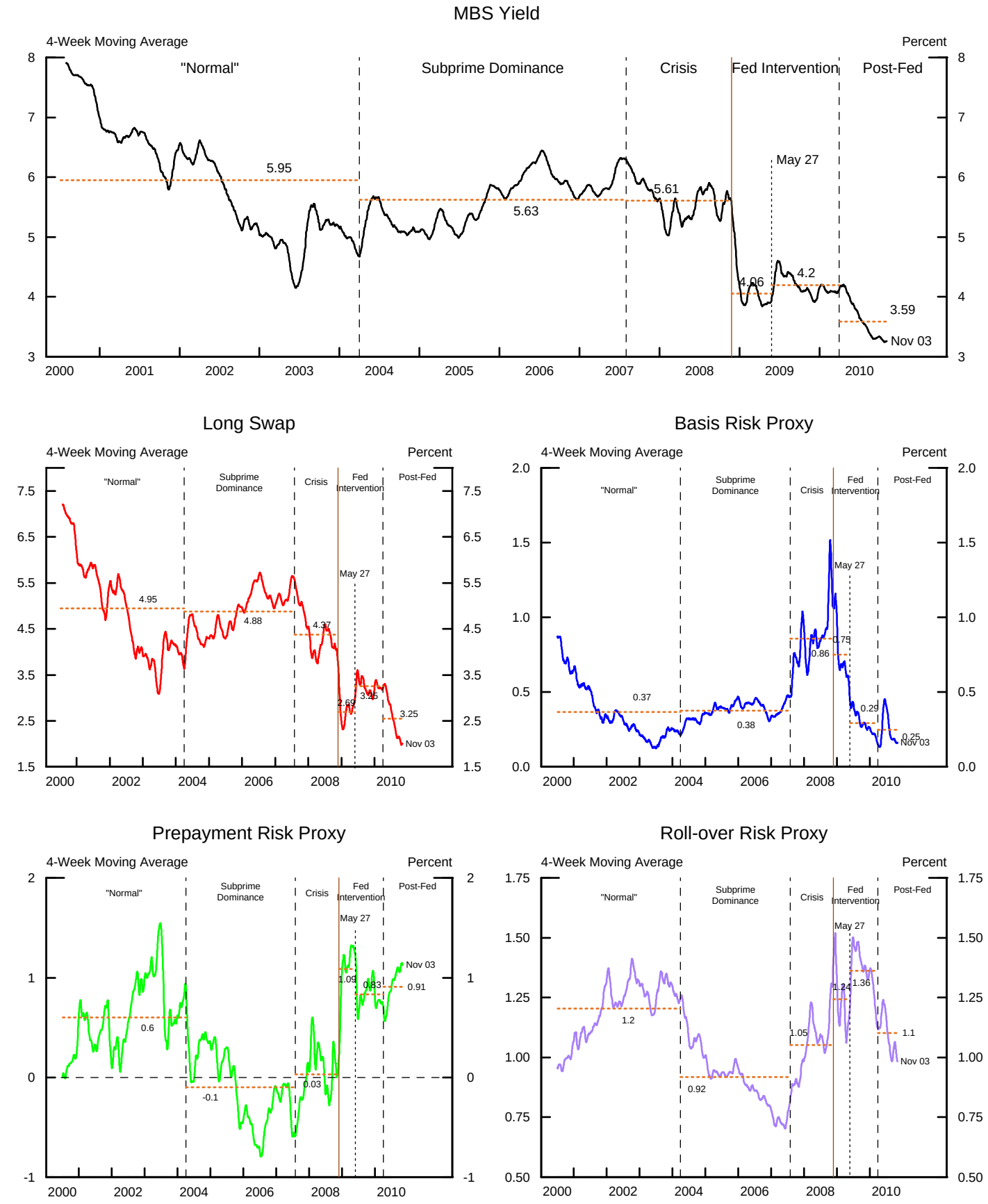


Source: Bloomberg

Note: Means in each era indicated by dashed lines

Figure 4

Components of the MBS Yield Regression



Sources: Bloomberg, Freddie Mac

Note: Means in each era indicated by dashed lines

Table 1

MBS Yield Regression: Estimates

"Normal" Period
Daily Data, Estimated Over July 2000 - March 2004 (n = 976)

		Parameter Estimate	*Standard Error*	*t Value*
	Factor	(1)	(2)	(3)
(1)	Long Swap Rate	1.06	0.01	76.66
(2)	Basis Risk Proxy	-0.19	0.06	-2.97
(3)	Prepayment Risk Proxy	0.25	0.02	11.54
(4)	Roll-over Risk Proxy	0.83	0.06	12.94
(5)	Intercept	-0.37	0.12	-2.99
(6)	Memo Item: R-Squared	0.99		

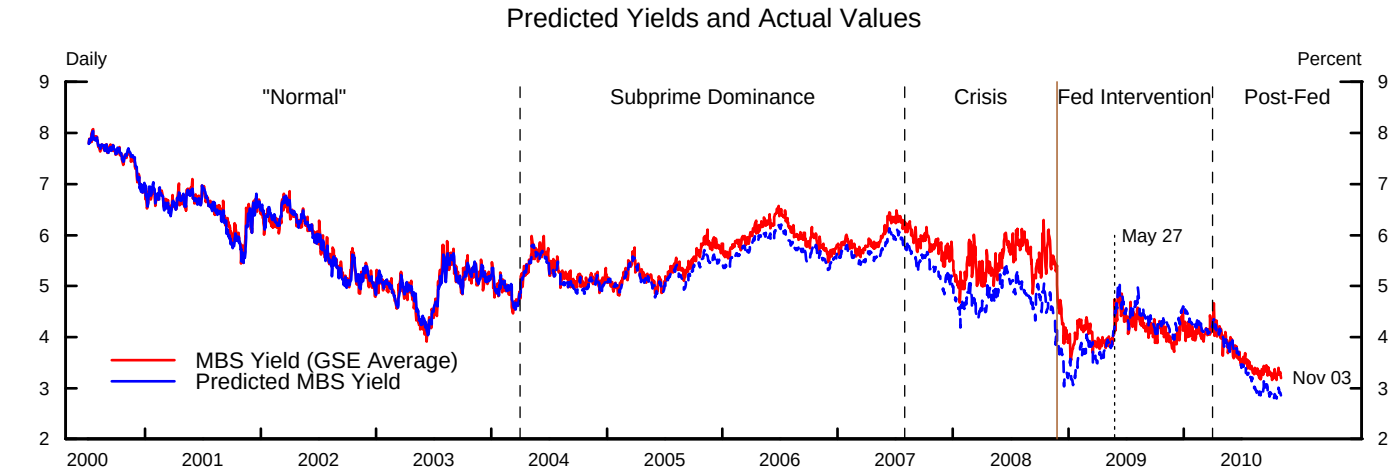
Subprime Dominance Period
Daily Data, Estimated Over April 2004 - July 2007 (n = 870)

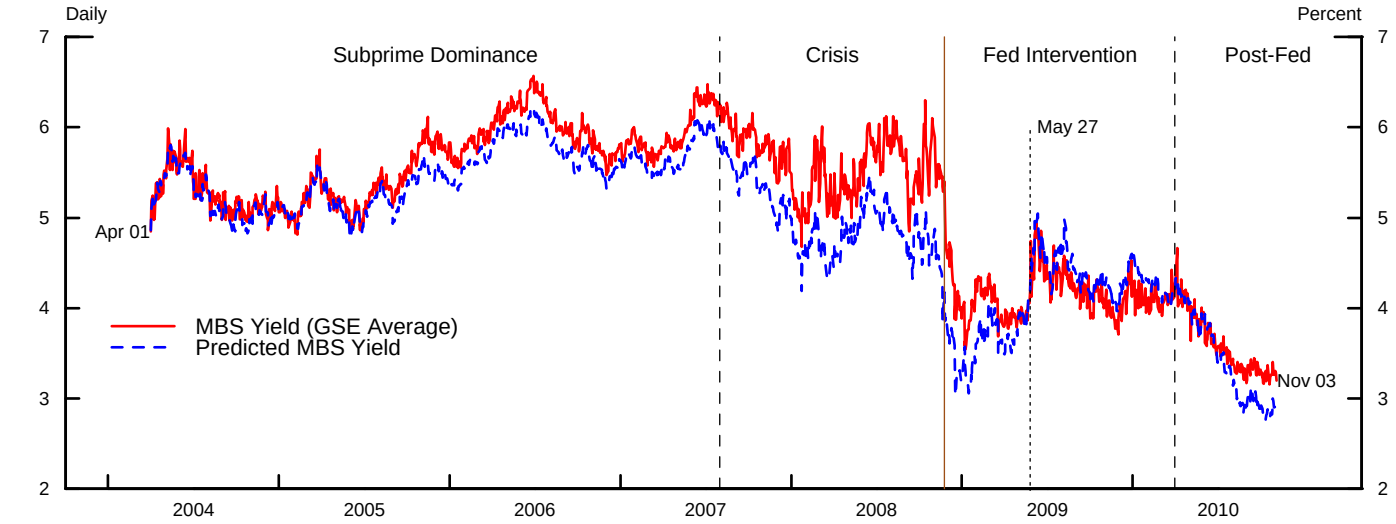
		Parameter Estimate	*Standard Error*	*t Value*
	Factor	(1)	(2)	(3)
(1)	Long Swap Rate	0.97	0.02	51.84
(2)	Basis Risk Proxy	-0.19	0.08	-2.26
(3)	Prepayment Risk Proxy	-0.04	0.03	-1.6
(4)	Roll-over Risk Proxy	0.56	0.03	17.63
(5)	Intercept	0.44	0.13	3.52
(6)	Memo Item: R-Squared	0.96		

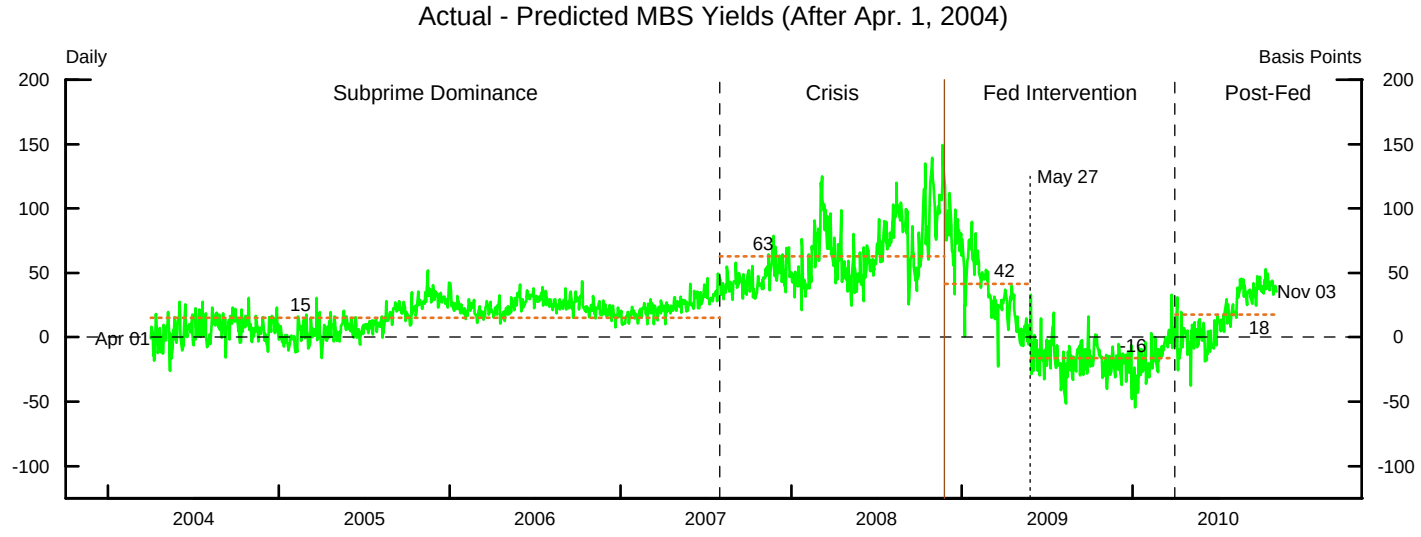
Sources of Data: Bloomberg, Freddie Mac

Figure 5

MBS Yield Regression: "Normal" Estimation





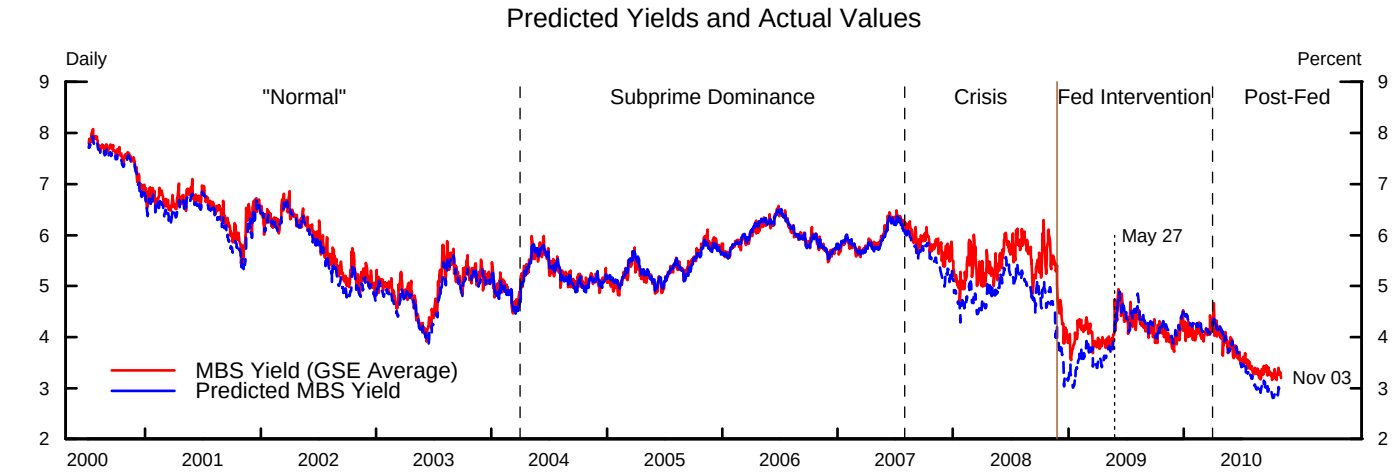


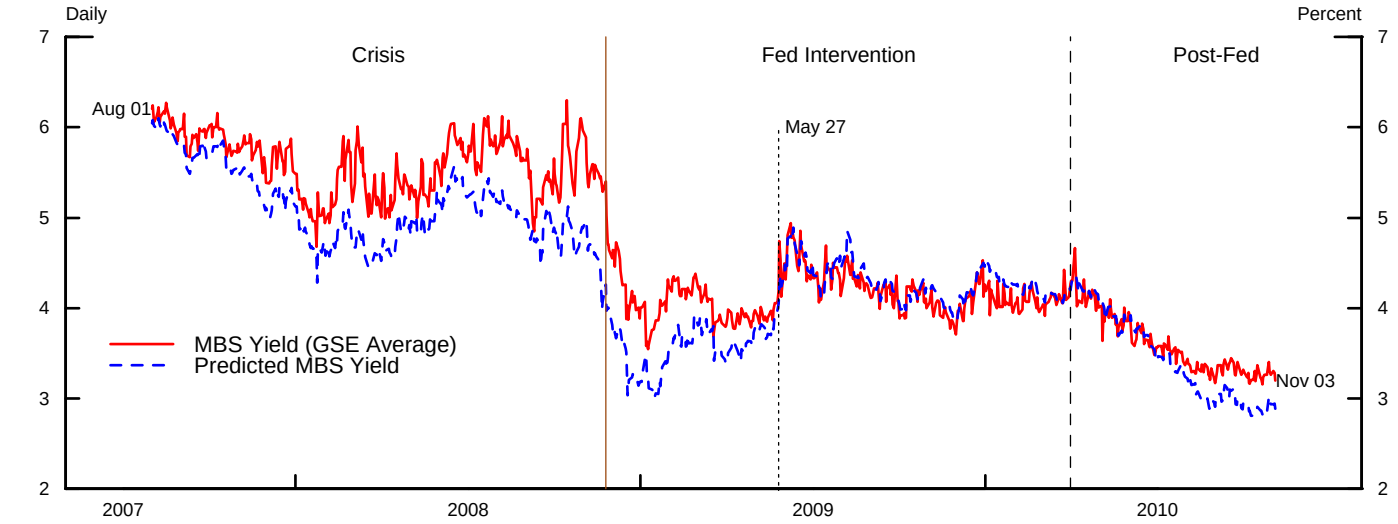
Sources: Authors' Estimates, Bloomberg

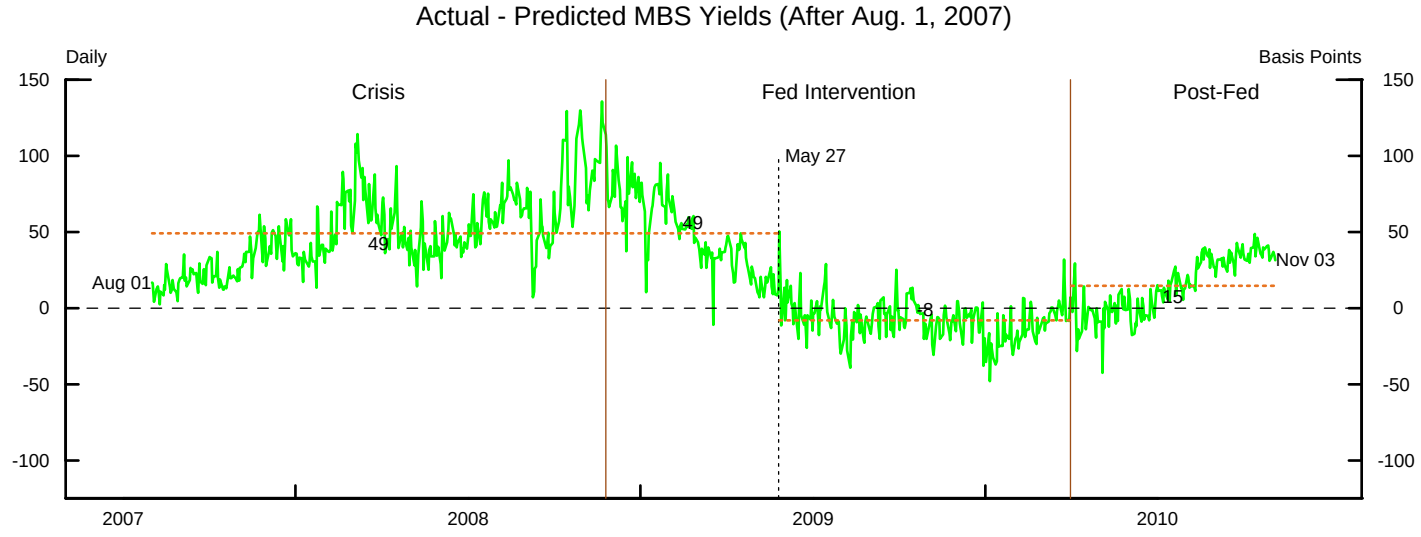
Note: Means in each era for "Actual - Predicted MBS Yields" indicated by dashed lines

Figure 6

MBS Yield Regression: Subprime Dominance Estimation



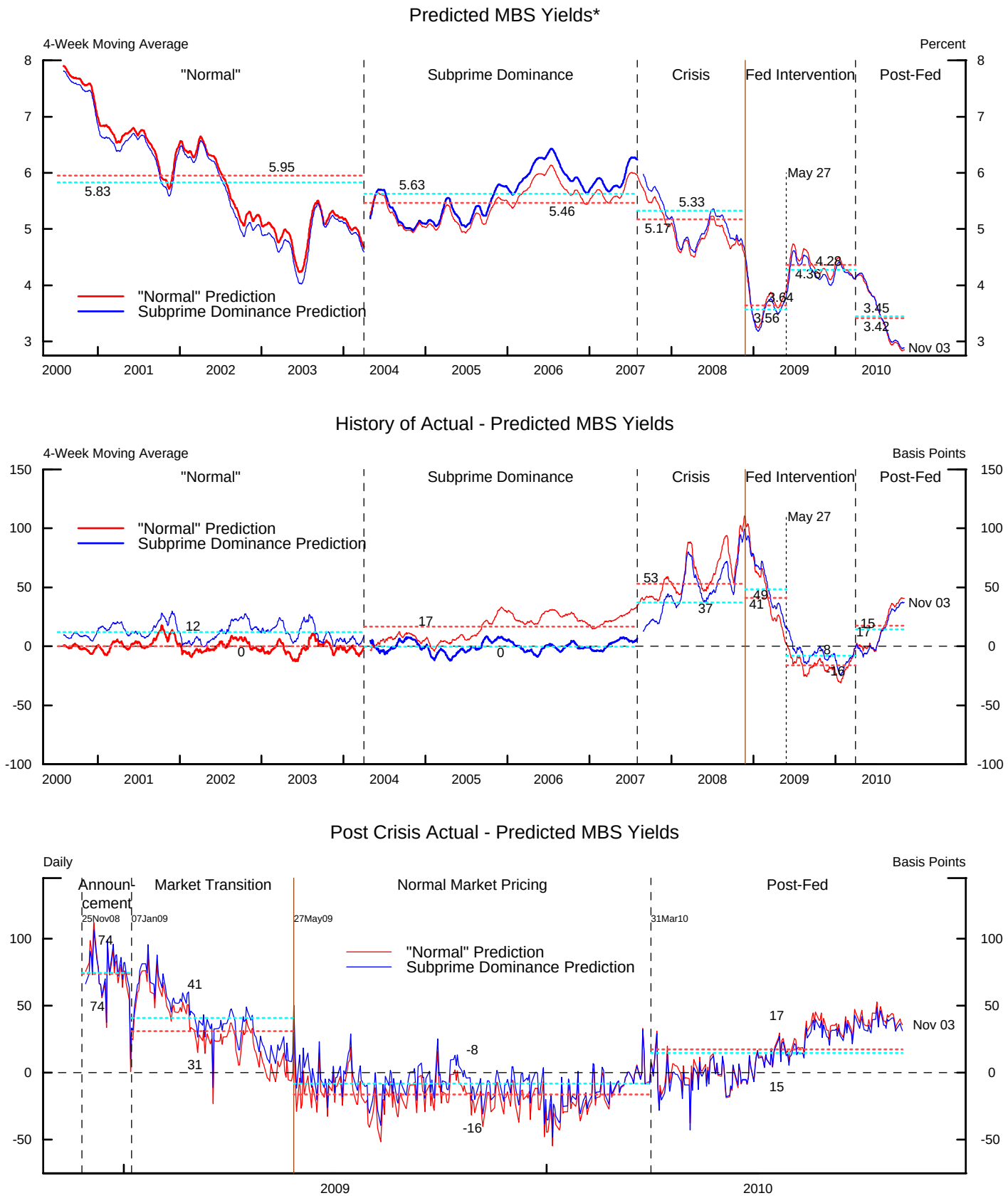




Sources: Authors' Estimates, Bloomberg

Note: Means in each era for "Actual - Predicted MBS Yields" indicated by dashed lines

Figure 7
Analysis of Changes in MBS Yields



Source: Authors' Estimates
* "Normal" era out-of-sample predictions (shown by the dashed red lines) based on estimation over July 2000 - Mar. 2004.
* Subprime dominance era out-of-sample predictions (shown by the dashed blue lines) based on estimation over Apr. 2004 - July 2007.
Note: Means in each era indicated by dashed lines

Table 2

Mortgage Rate Regression: Estimates

"Normal" Period
Weekly Data, Estimated Over July 2000 - March 2004 (n = 186)

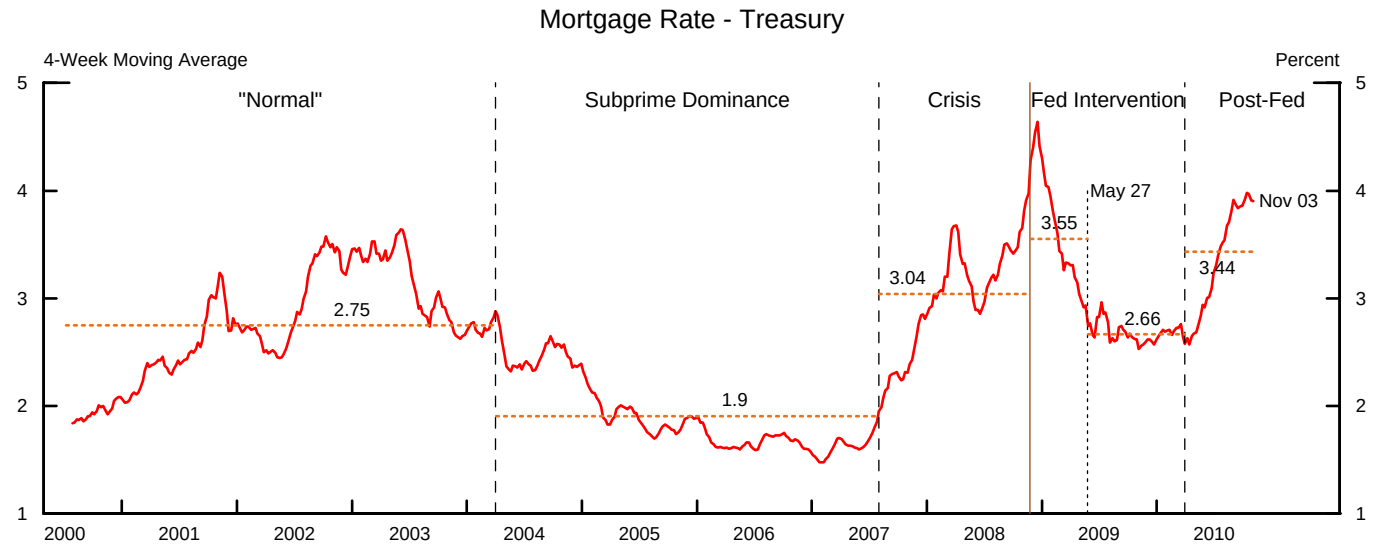
		Parameter Estimate	*Standard Error*	*t Value*
	Factor	(1)	(2)	(3)
(1)	MBS Yield (1-Week Lag)	0.64	0.02	33.78
(2)	Home Price Index (10-Week Lag)	-0.51	0.09	-5.88
(3)	Intercept	3.58	0.24	14.73
(4)	Memo Item: R-Squared	0.97		

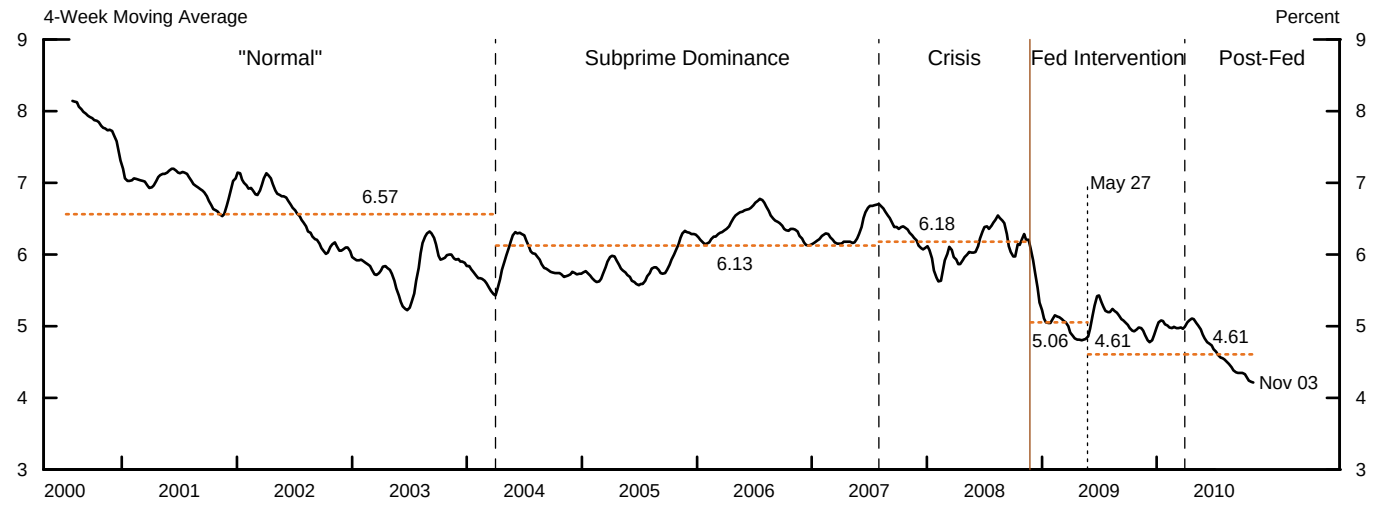
Subprime Dominance Period
Weekly Data, Estimated Over April 2004 - July 2007 (n = 174)

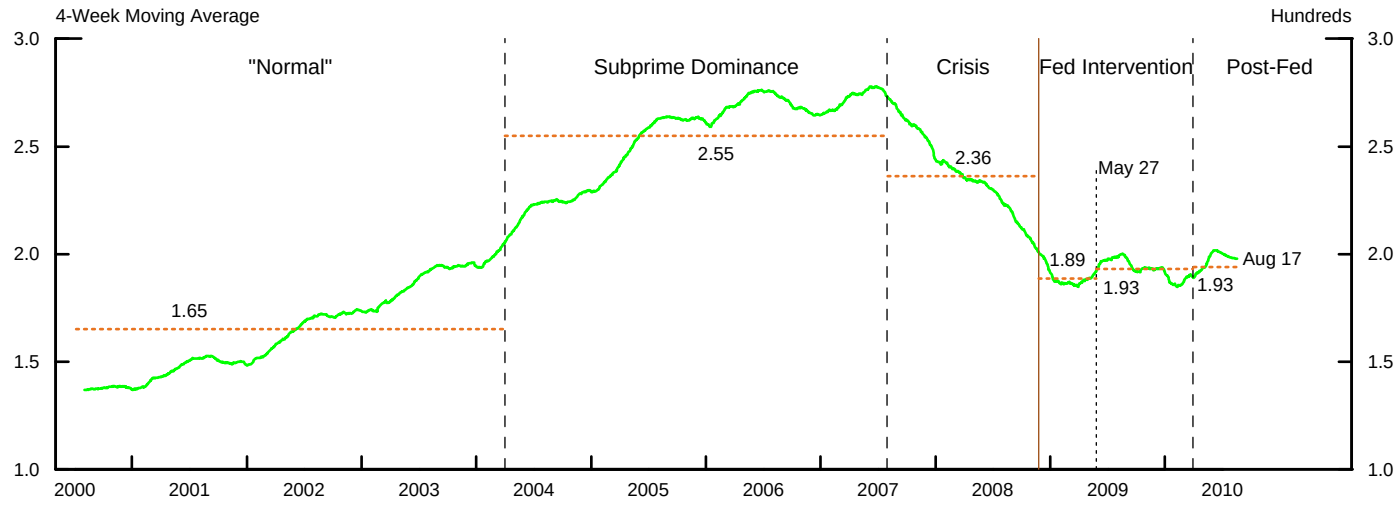
		Parameter Estimate	*Standard Error*	*t Value*
	Factor	(1)	(2)	(3)
(1)	MBS Yield (1-Week Lag)	0.85	0.02	39.89
(2)	Home Price Index (10-Week Lag)	-0.18	0.04	-4.72
(3)	Intercept	1.82	0.09	21.02
(4)	Memo Item: R-Squared	0.94		

Sources of Data: Authors' Estimates, Radar Logic

Figure 8
Primary Mortgage Market Characteristics



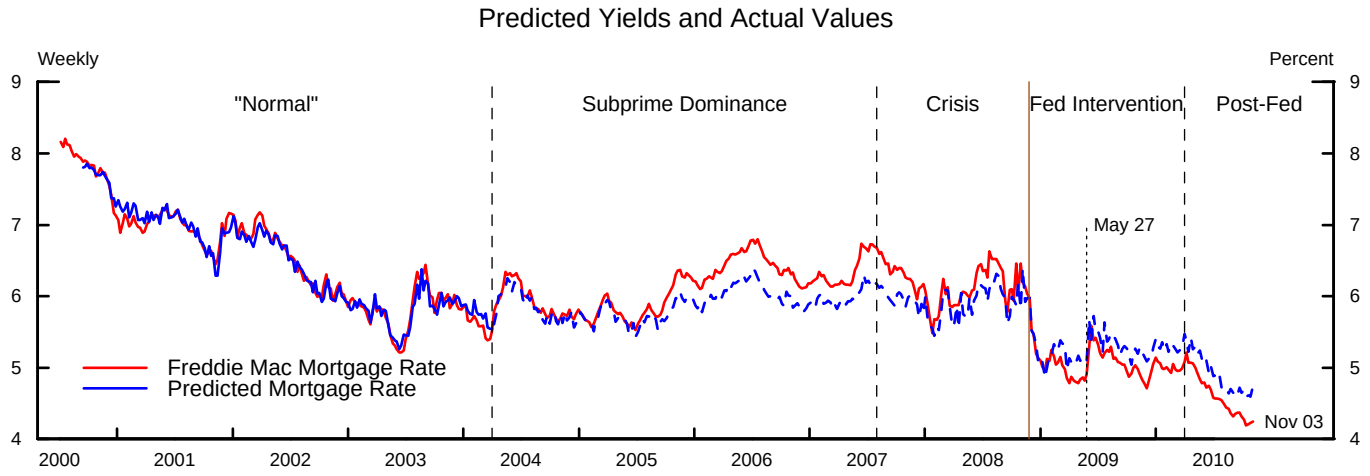


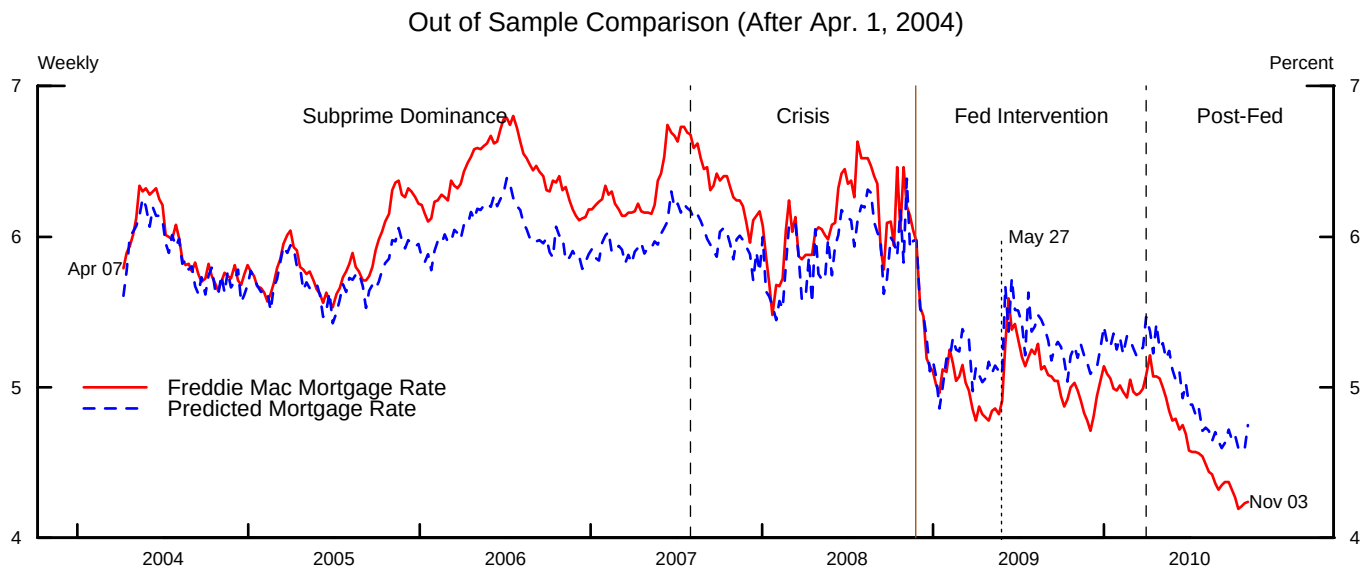


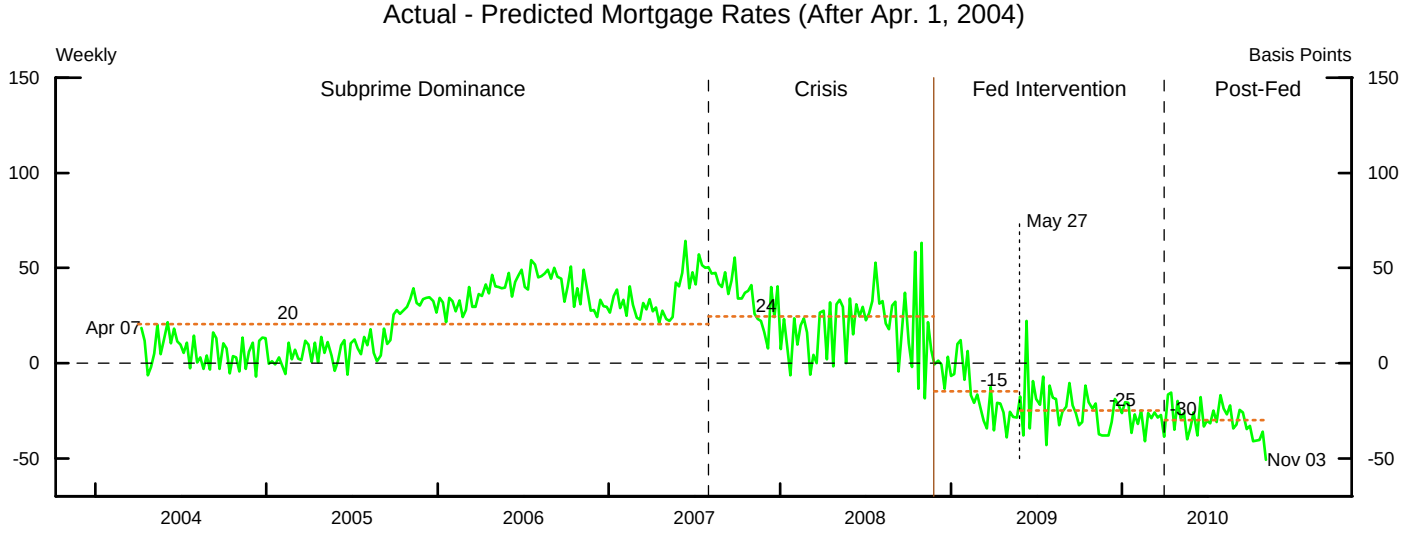
Sources: Freddie Mac, Radar Logic
Note: Means in each era indicated by dashed lines

Figure 9

Mortgage Rate Regression: "Normal" Estimation





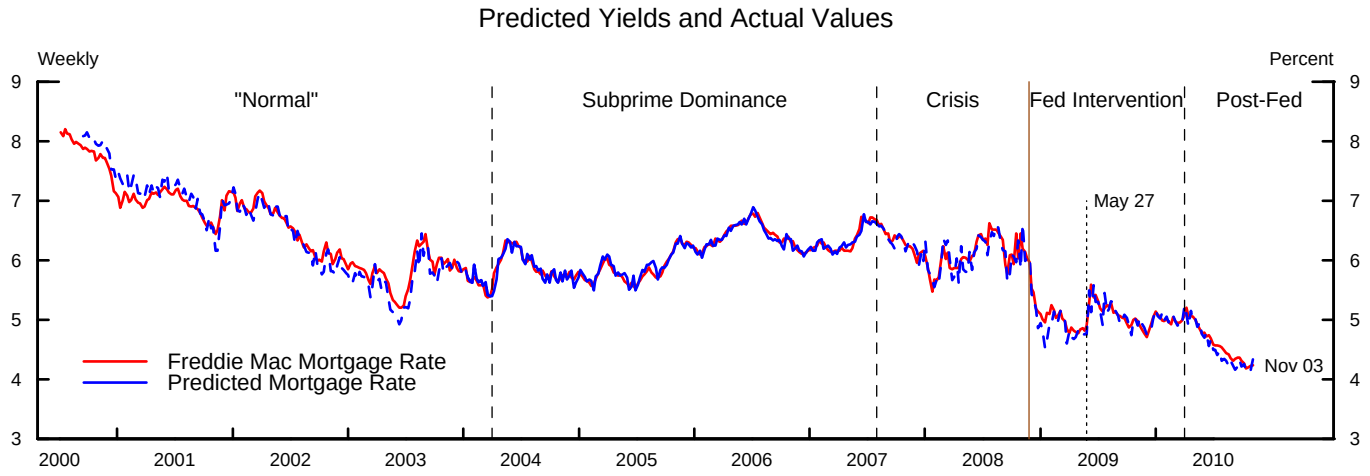


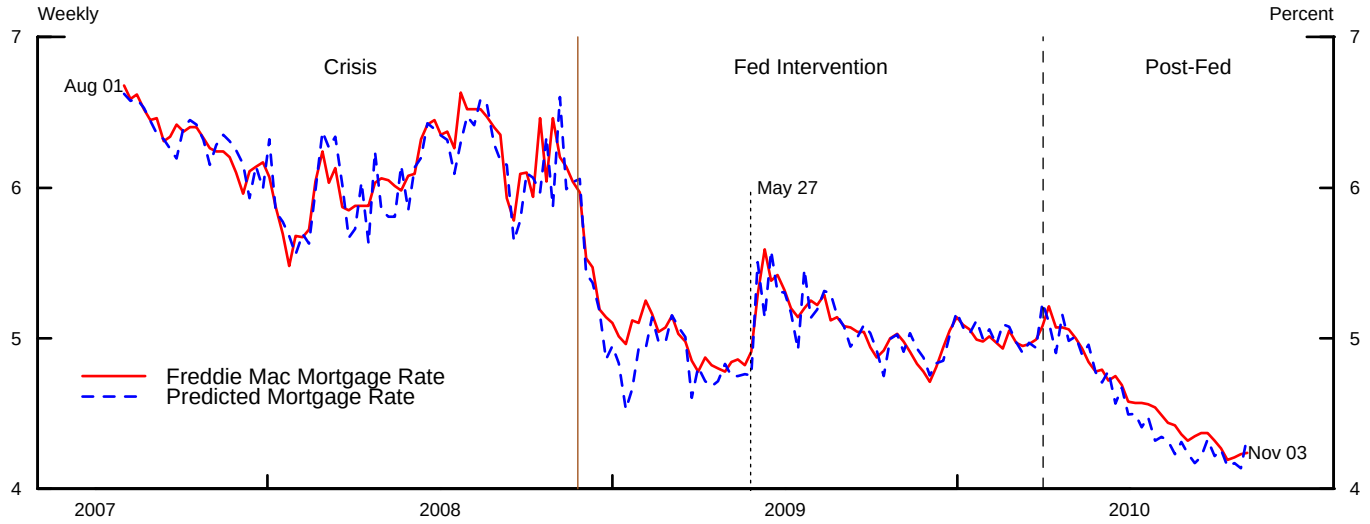
Sources: Authors' Estimates, Freddie Mac

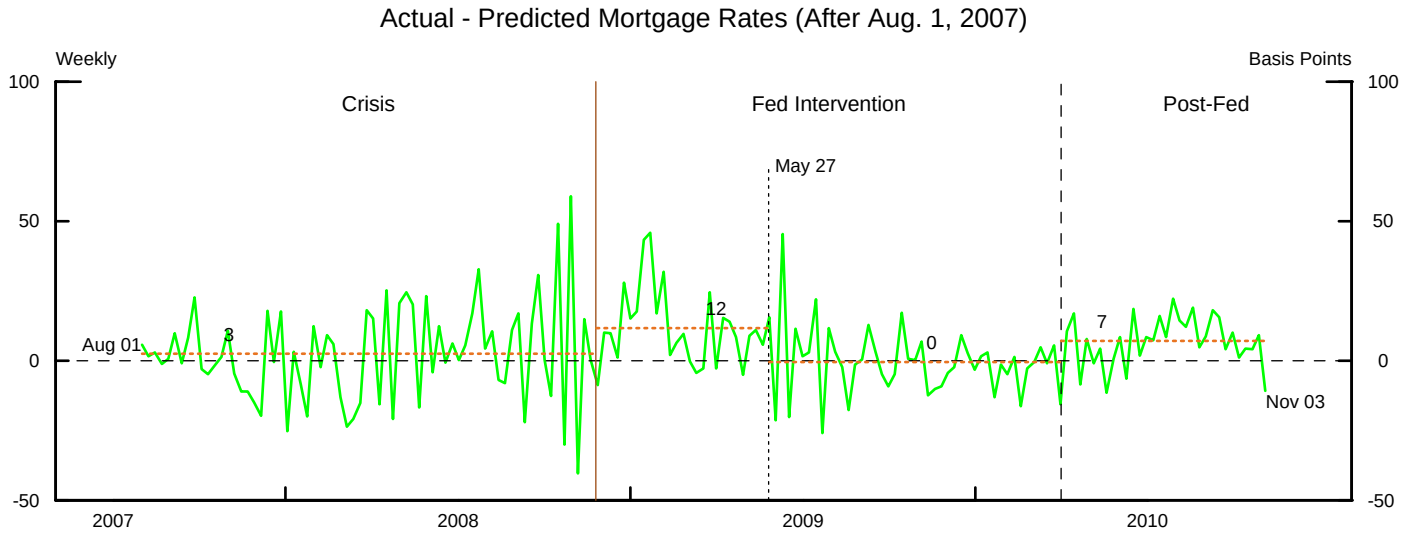
Note: Means in each era for "Actual - Predicted Mortgage Rates" indicated by dashed lines

Figure 10

Mortgage Rate Regression: Subprime Dominance Estimation



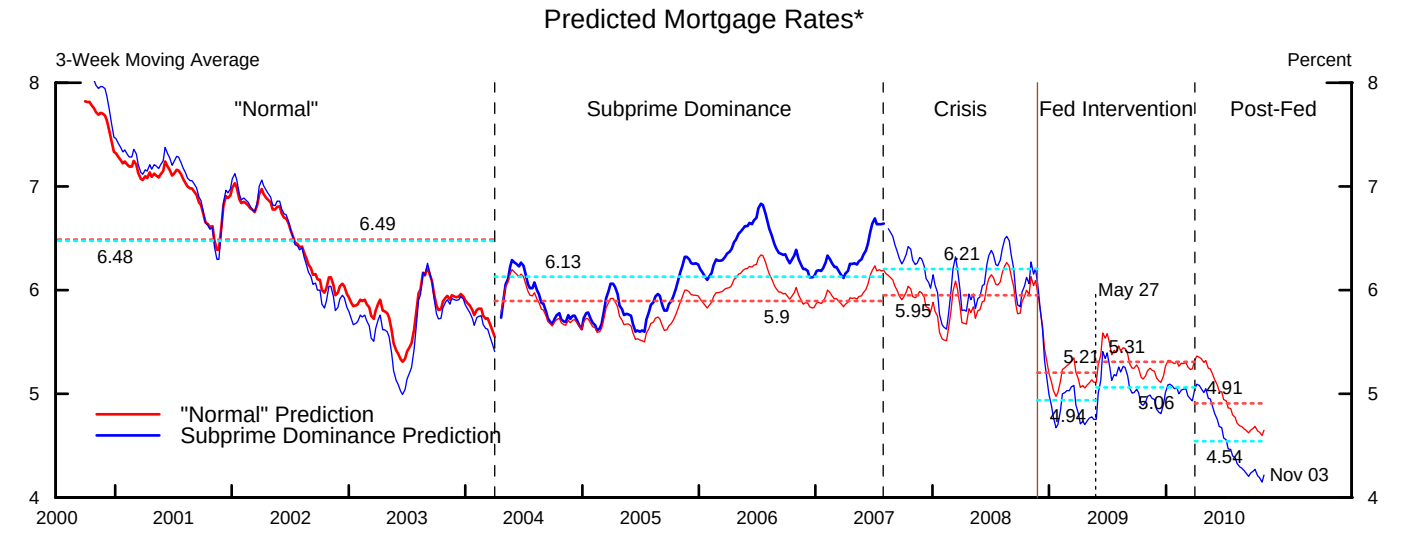


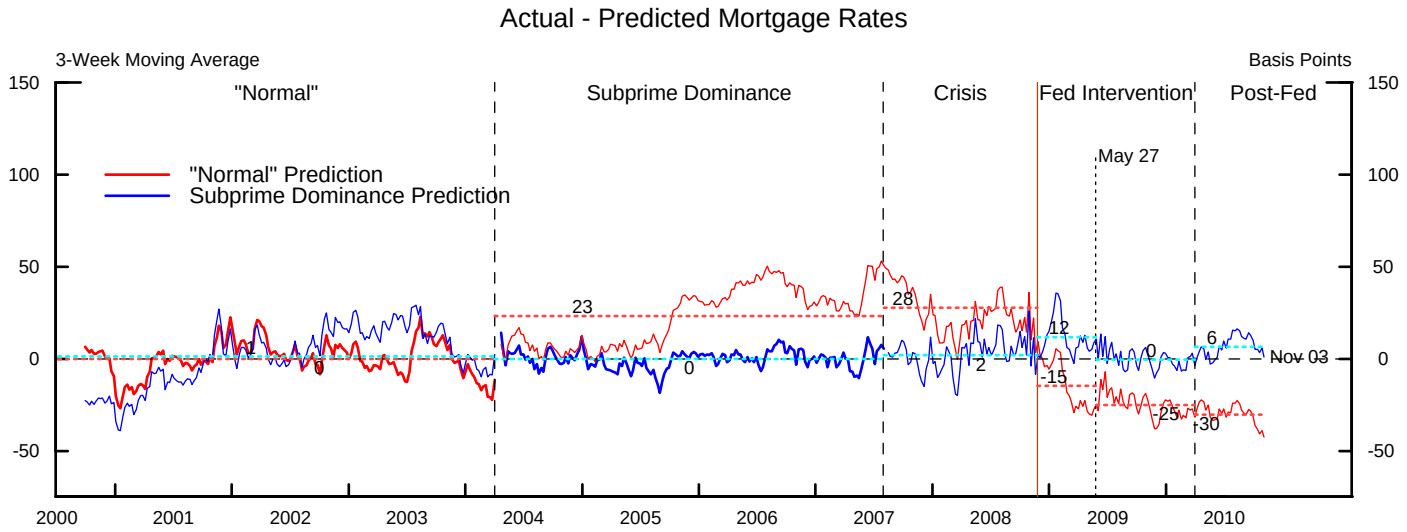


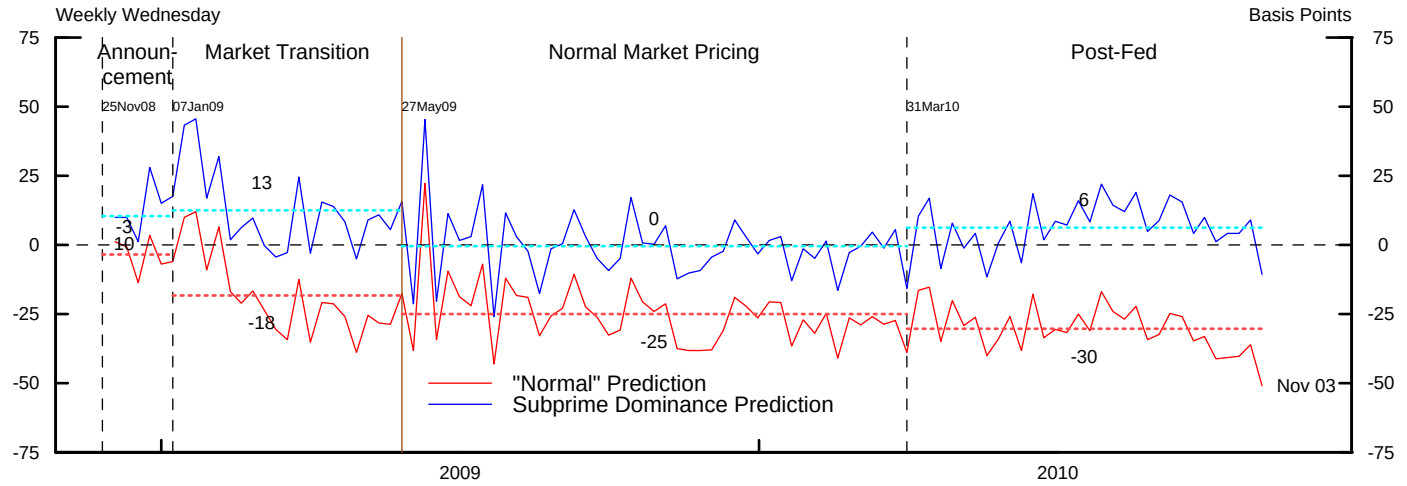
Sources: Authors' Estimates, Freddie Mac

Note: Means in each era for "Actual - Predicted Mortgage Rates" indicated by dashed lines

Figure 11
Analysis of Changes in the Mortgage Rate

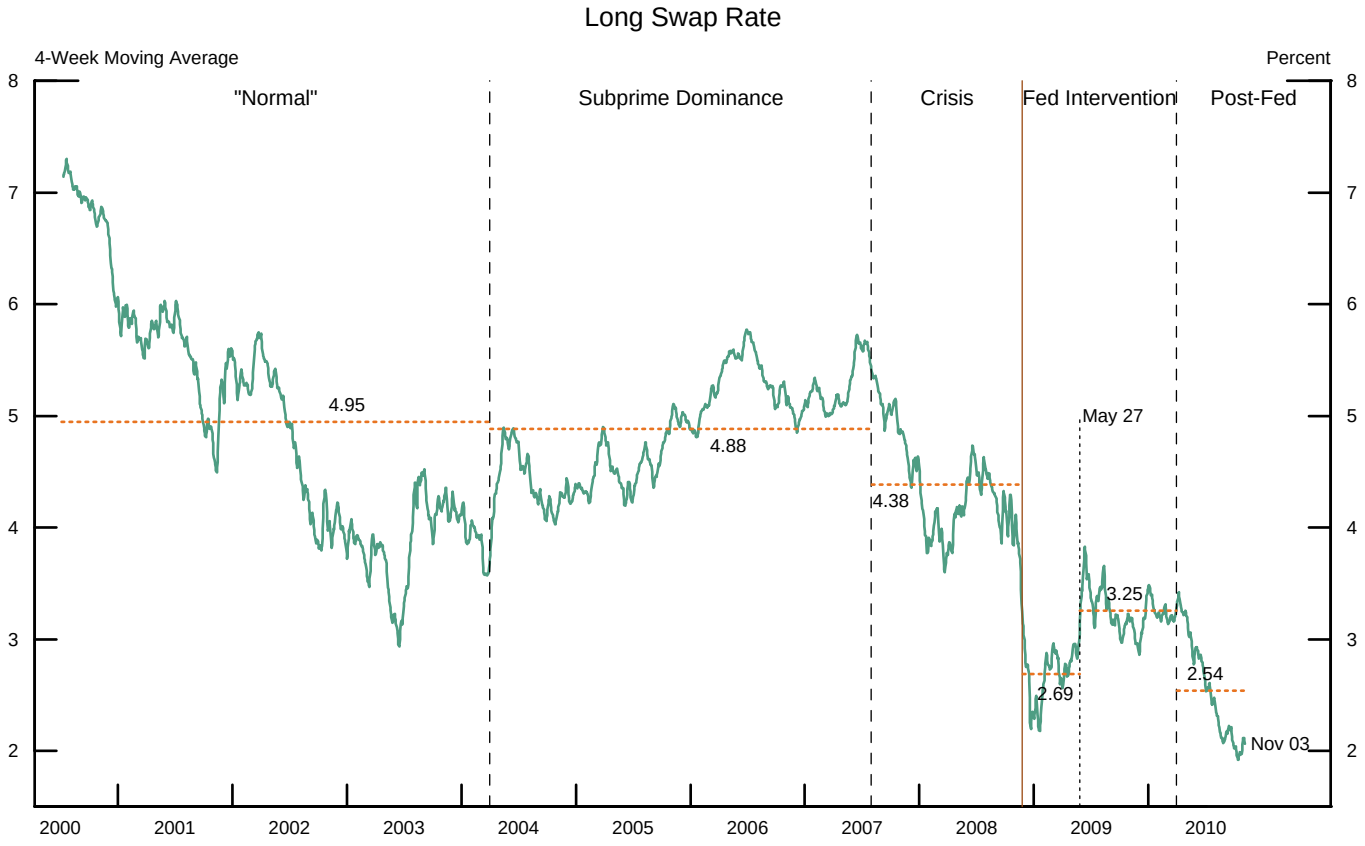


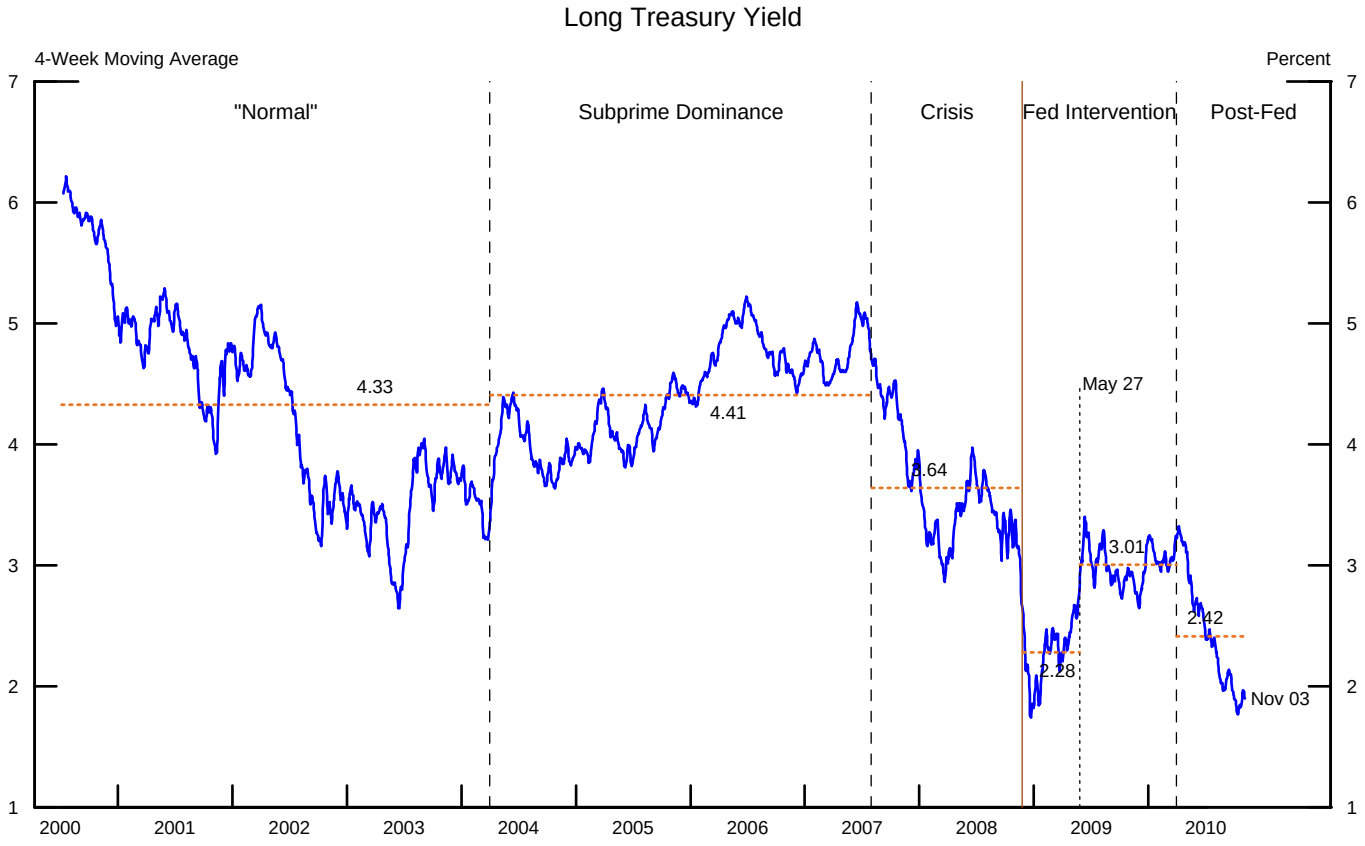




Source: Authors' Estimates
* "Normal" period out-of-sample predictions (shown by the dashed red lines) based on estimation over July 2000 - Mar. 2004.
* Subprime Dominance period out-of-sample predictions (shown by the dashed blue lines) based on estimation over Apr. 2004 - July 2007.
Note: Means in each era indicated by dashed lines

Figure 12
Components of the Swap Rate Regression

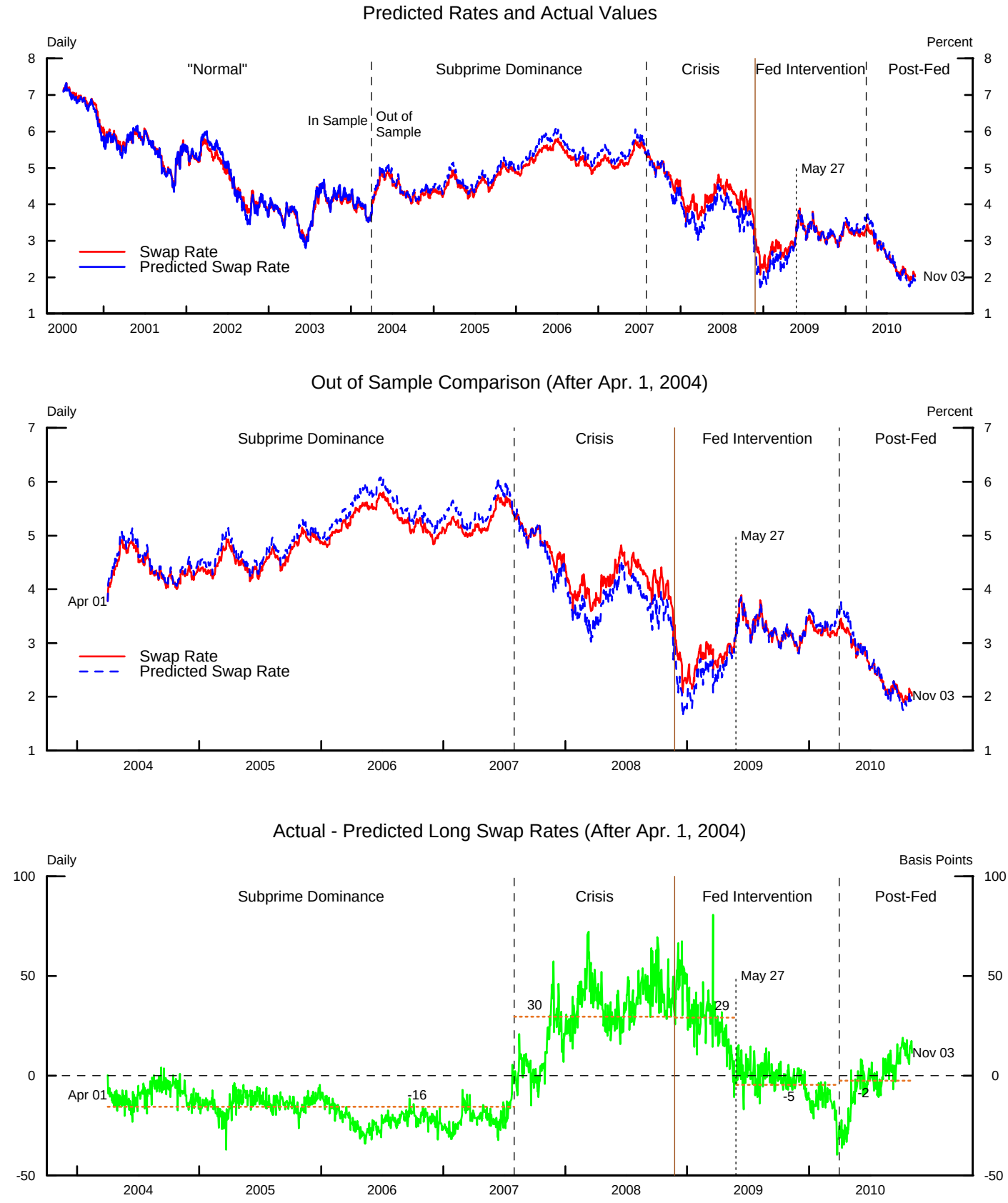




Sources: Authors' Estimates, Freddie Mac
Note: Means in each era for "Actual - Predicted Long Swap Rates" indicated by dashed lines

Figure 13

Long Swap Rate Regression: "Normal" Estimation

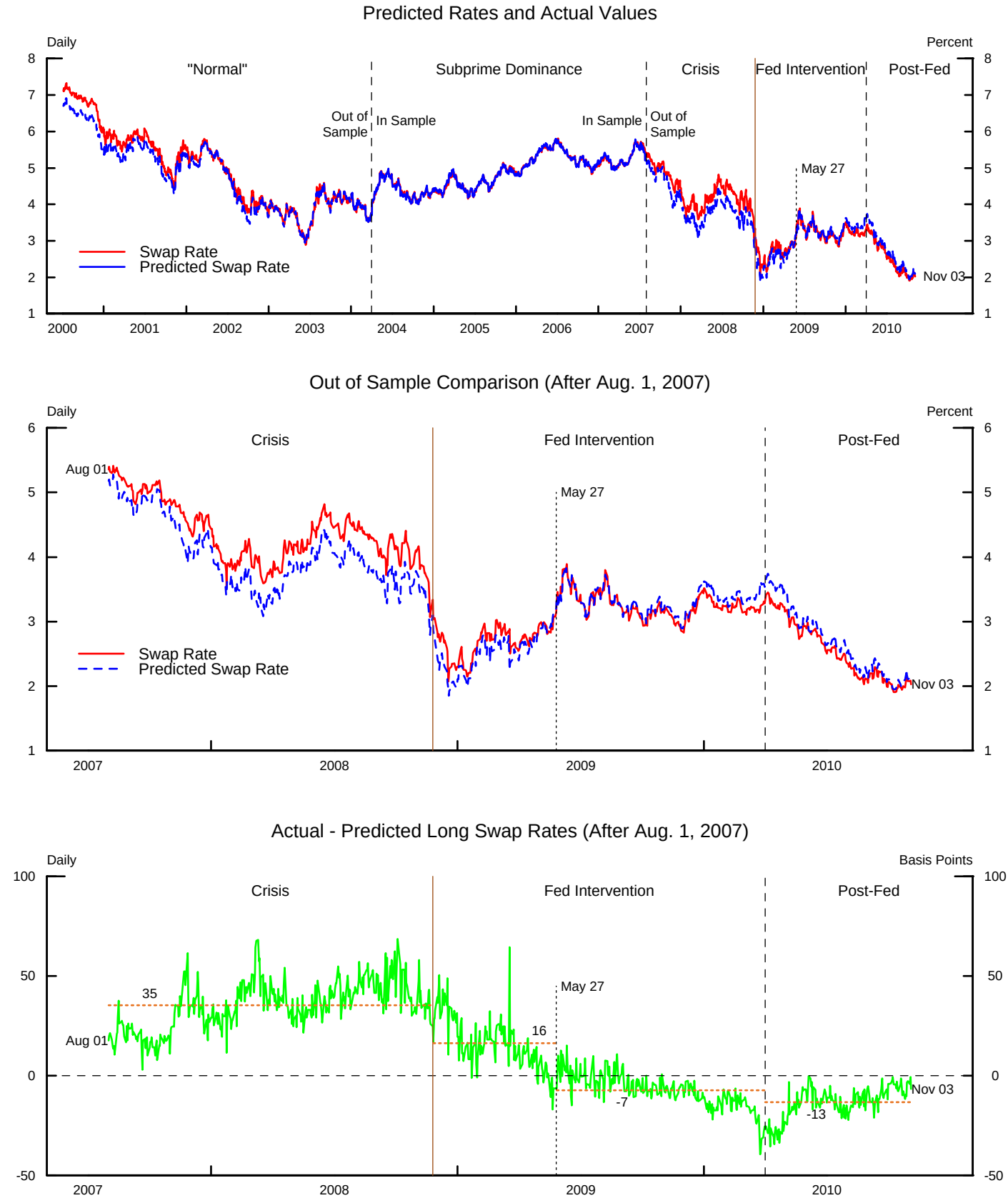


Source: Authors' Estimates

Note: Means in each era for "Actual - Predicted Long Swap Rates" indicated by dashed lines

Figure 14

Long Swap Rate Regression: Subprime Dominance Estimation



Source: Authors' Estimates

Table 3

Long Swap Rate Regression: Estimates

"Normal" Period
Daily Data, Estimated Over July 2000 - March 2004 (n = 976)

		Parameter Estimate	*Standard Error*	*t Value*
	Factor	(1)	(2)	(3)
(1)	Long Treasury Yield	1.24	0	285.49
(2)	Intercept	-0.44	0.02	-23
(3)	Memo Item: R-Squared	0.99		

Subprime Dominance Period
Daily Data, Estimated Over April 2004 - July 2007 (n = 870)

		Parameter Estimate	*Standard Error*	*t Value*
	Factor	(1)	(2)	(3)
(1)	Long Treasury Yield	1.11	0	306.86
(2)	Intercept	0	0.02	-0.16
(3)	Memo Item: R-Squared	0.99		

Sources of Data: Authors' Estimates, Bloomberg

Table 4

Changes in Mortgage Rates, MBS Yields, Swap Rates, Estimates and Deviations of Estimates Thereof, By Period

Period of Interest	Actual Data			Predicted Values						Deviations (Actual - Predicted)					
				Mortgage Rate		MBS Yield		Swap Rate		Mortgage Rate		MBS Yield		Swap Rate	
	Mort. Rate	MBS Yield	Swap Rate	*N*	*S*	*N*	*S*	*N*	*S*	*N*	*S*	*N*	*S*	*N*	*S*
Nov. 25, 2008 - Jan. 7, 2009	-0.97	-1.27	-0.70	-0.84	-1.15	-0.58	-0.76	-0.66	-0.58	-0.12	0.18	-0.69	-0.51	-0.04	-0.11
Jan. 7, 2009 - May 27, 2009	-0.22	0.57	0.86	0.00	-0.13	0.98	0.89	1.16	1.03	-0.22	-0.09	-0.41	-0.32	-0.30	-0.17
May 27, 2009 - Mar. 31, 2010	0.15	-0.04	0.07	0.21	0.29	-0.09	0.08	0.37	0.33	-0.07	-0.15	0.05	-0.12	-0.30	-0.26
Mar. 31, 2010 - Present	-0.78	-0.94	-1.24	-0.67	-0.83	-1.24	-1.20	-1.65	-1.47	-0.11	0.05	0.30	0.26	0.41	0.23

Sources: Authors' Estimates, Reuters, Treasury Dept., FRBNY, ISDA, Bloomberg, Freddie Mac, Radar Logic

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Note: N and S represent the Normal and Subprime periods, respectively

Table 5

Market Functioning and Portfolio Rebalancing Effects in the Mortgage Market
(Changes in the Components of the Mortgage Rate)

Period of Interest	Morgage Rate (1)	Abnormal Mortgage Pricing (2)		Abnormal MBS Pricing (3)		Predicted MBS Level (4)		Primary Mortgage Market Cost (5)		Long Swap Rate Effect* (6)	
		N	S	N	S	N	S	N	S	N	S
(1) Announcement Nov. 25, 2008 - Jan. 7, 2009	-97	-12	18	-44	-43	-37	-65	9	3	-47	-57
(2) Market Transition Jan. 7, 2009 - May 27, 2009	-22	-22	-9	-26	-27	63	76	-8	-3	58	71
(3) Normal Pricing May 27, 2009 - Mar. 31, 2010	15	-7	-15	3	-10	-6	7	1	0	5	6
(4) Post-Fed Mar. 31, 2010 - Present	-78	-11	5	20	22	-79	-102	-3	-1	-84	-102

Sources: Bloomberg
Note: N and S represent the Normal and Subprime periods, respectively
*Memorandum item: Calculation of the effect of changes in the long term swap rate on the predicted MBS yield

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Appendix - Table 1

Description of Data

	Description	*Source*
Basis Risk Proxy	Spread of 1.5-year swap rate minus the 1.5-year Treasury yield Calculated as an average of 1- and 2-year yields/rates	Treasury/FRBNY Reuters Limited/ISDA
Home Price Index	25-MSA composite, 7-day average of the price-per-square foot paid for residential real estate Transformed into hundreds to roughly match scale of other regressors	Radar Logic
Long Swap Rate	7.5-year swap rate Calculated as an average of 5- and 10-year rates	Reuters Limited/ISDA
Long Treasury Rate	7.5-year Treasury yield Calculated as an average of 5- and 10-year yields	Treasury/FRBNY
MBS Yield	Average of Fannie Mae and Freddie Mac current-coupon MBS yields Yields given by weighted average of Bloomberg generic MBS yields bracketing current mortgage rate (with 50 bp haircut)	Derived from Bloomberg
Mortgage Rate	Freddie Mac 30-year primary mortgage market survey rate	Freddie Mac
Prepayment Risk Proxy	Spread of 3-year moving average minus weekly value, of Freddie Mac 30-year primary mortgage market survey rate	Freddie Mac
Roll-over Risk Proxy	Width of the 90-percent confidence interval of the 2-year 10 years ahead forward swap rate (assuming a lognormal distribution)	Derived from Bloomberg

Appendix - Table 1

Description of Data

	Description	*Source*
Federal Reserve Purchases	MBS purchases by Federal Reserve (Daily; Billions of dollars outstanding).	FRBNY
Gross MBS Issuance	Gross Issuance of Freddie Mac, Fannie Mae, and Ginnie Mae MBS. Backed by 30 year fixed-rate mortgages (Monthly; Billions of dollars outstanding).	embs.com
Outstanding Federal Reserve MBS	Total holdings of MBS held by Federal Reserve (Daily; Billions of dollars outstanding). Freddie Mac, Fannie Mae, and Ginnie Mae MBS. Backed by 30 year fixed-rate mortgages.	FRBNY
Total MBS Stock	Total MBS in market place (Daily; Billions of dollars outstanding). Freddie Mac, Fannie Mae, and Ginnie Mae MBS. Backed by 30 year fixed-rate mortgages.	embs.com

Appendix - Table 2

Means and Standard Deviations of Data and Estimates, By Period

	Normal	*Subprime Dominance*	*Crisis*	*Announcement*
Basis Risk Proxy	0.37	0.38	0.86	1.07
	(0.19)	(0.05)	(0.2)	(0.08)
Home Price Index	1.65	2.55	2.36	1.92
	(0.21)	(0.2)	(0.19)	(0.08)
Long Swap (Actual)	4.95	4.88	4.37	2.55
	(1.08)	(0.46)	(0.47)	(0.27)
Long Swap (Predicted, Normal)	4.95	5.04	4.07	2.08
	(1.07)	(0.51)	(0.6)	(0.27)
Long Swap (Predicted, Subprime)	4.79	4.88	4.01	2.24
	(0.95)	(0.46)	(0.54)	(0.24)
Long Treasury	4.33	4.41	3.63	2.03
	(0.86)	(0.41)	(0.48)	(0.22)
MBS Yield (Actual)	5.95	5.63	5.6	4.22
	(0.96)	(0.42)	(0.33)	(0.33)
MBS Yield (Predicted, Normal)	5.95	5.46	4.97	3.5
	(0.96)	(0.33)	(0.38)	(0.25)
MBS Yield (Predicted, Subprime)	5.83	5.63	5.11	3.49
	(0.97)	(0.41)	(0.42)	(0.3)
Mortgage Rate (Actual)	6.57	6.13	6.17	5.34
	(0.74)	(0.34)	(0.26)	(0.34)
Mortgage Rate (Predicted, Normal)	6.49	5.9	5.93	5.38
	(0.66)	(0.2)	(0.21)	(0.32)
Mortgage Rate (Predicted, Subprime)	6.48	6.13	6.15	5.24
	(0.79)	(0.33)	(0.28)	(0.43)
Prepayment Risk Proxy	0.6	-0.1	0.03	0.74
	(0.35)	(0.37)	(0.26)	(0.32)
Roll-over Risk Proxy	1.2	0.92	1.05	1.42
	(0.12)	(0.13)	(0.13)	(0.08)

Sources: Authors' Estimates, Reuters, Treasury Dept., FRBNY, ISDA, Bloomberg, Freddie Mac, Radar Logic
Standard deviations shown in parentheses

Appendix - Table 2

Means and Standard Deviations of Data and Estimates, By Period

	Market Transition	*Normal Pricing*	*Post-Fed*	*All*
Basis Risk Proxy	0.65	0.29	0.25	0.44
	(0.07)	(0.07)	(0.11)	(0.24)
Home Price Index	1.87	1.92	1.98	2.08
	(0.04)	(0.06)	(0.04)	(0.43)
Long Swap (Actual)	2.74	3.25	2.54	4.47
	(0.22)	(0.19)	(0.45)	(1.08)
Long Swap (Predicted, Normal)	2.51	3.3	2.56	4.47
	(0.29)	(0.21)	(0.57)	(1.14)
Long Swap (Predicted, Subprime)	2.62	3.33	2.67	4.37
	(0.26)	(0.18)	(0.51)	(1.02)
Long Treasury	2.37	3.01	2.42	3.95
	(0.24)	(0.17)	(0.46)	(0.92)
MBS Yield (Actual)	4.01	4.2	3.59	5.43
	(0.2)	(0.22)	(0.33)	(0.97)
MBS Yield (Predicted, Normal)	3.69	4.36	3.41	5.28
	(0.26)	(0.22)	(0.48)	(1)
MBS Yield (Predicted, Subprime)	3.6	4.28	3.44	5.3
	(0.23)	(0.2)	(0.48)	(1)
Mortgage Rate (Actual)	4.96	5.06	4.59	6.06
	(0.15)	(0.18)	(0.3)	(0.78)
Mortgage Rate (Predicted, Normal)	5.15	5.31	4.89	5.97
	(0.13)	(0.15)	(0.26)	(0.64)
Mortgage Rate (Predicted, Subprime)	4.84	5.07	4.52	6.01
	(0.18)	(0.18)	(0.32)	(0.79)
Prepayment Risk Proxy	1.2	0.83	0.91	0.36
	(0.09)	(0.13)	(0.19)	(0.52)
Roll-over Risk Proxy	1.19	1.36	1.1	1.1
	(0.07)	(0.1)	(0.08)	(0.19)

Sources: Authors' Estimates, Reuters, Treasury Dept., FRBNY, ISDA, Bloomberg, Freddie Mac, Radar Logic
Standard deviations shown in parentheses