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Andreas Lehnert, Wayne Passmore, and Shane M. Sherlund

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Andreas Lehnert
Board of Governors of the
Federal Reserve System
Washington, DC 20551
(202) 452-3325
Andreas.Lehnert@frb.gov

Wayne Passmore
Board of Governors of the
Federal Reserve System
Washington, DC 20551
(202) 452-6432
Wayne.Passmore@frb.gov

Shane M. Sherlund
Board of Governors of the
Federal Reserve System
Washington, DC 20551
(202) 452-3589
Shane.M.Sherlund@frb.gov

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GSEs, Mortgage Rates, and Secondary Market Activities

Abstract

Fannie Mae and Freddie Mac are government-sponsored enterprises (GSEs) that purchase mortgages and issue mortgage-backed securities (MBS). In addition, the GSEs are active participants in the primary and secondary mortgage markets on behalf of their own portfolios of MBS. Because these portfolios have grown quite large, portfolio purchases as well as MBS issuance are likely to be important forces in the mortgage market. This paper examines the statistical evidence of a connection between GSE actions and the interest rates paid by mortgage borrowers. We find that both portfolio purchases and MBS issuance have negligible effects on mortgage rate spreads and that purchases are not any more effective than securitization at reducing mortgage interest rate spreads. We also examine the 1998 liquidity crisis and find that GSE portfolio purchases did little to affect interest rates paid by borrowers. These results are robust to alternative assumptions about causality and to model specification.

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1 Introduction and Summary

The housing-related government-sponsored enterprises (GSEs) Fannie Mae and Freddie Mac buy mortgages from originators and use them to issue mortgage-backed securities (MBS). These GSEs also keep many mortgages in their own portfolios, either as whole loans or as MBS. By 2003, these portfolios amounted to almost $1.5 trillion of home mortgages, or more than 22 percent of the entire home mortgage market.

Earnings from mortgages held in portfolio clearly benefit GSE shareholders. The GSEs' portfolio holdings may also benefit mortgage originators and, to some degree, homeowners with conforming mortgages.[1] In particular, unusually heavy and sustained portfolio purchases by GSEs might bid up the price of new mortgages, allowing originators to profit more or giving originators greater scope to lower mortgage interest rates paid by new borrowers.

GSE actions, however, may not be special. Many loans other than conforming mortgages are securitized; in these markets a variety of primary market originators sell loans to secondary market entities for securitization. These other markets do not feature GSEs; instead, participants are purely private entities. Nonetheless, in a competitive equilibrium, total secondary market purchases and mortgage market

[1] One oft-cited measure of the benefit the GSEs pass through to mortgage borrowers is the so-called jumbo-conforming spread, that is, the difference in interest rates paid by borrowers with conforming mortgages and those with mortgages that are too large to be bought by the GSEs (jumbos). Estimates of this spread range from 16 to 27 basis points; see McKenzie (2002); Ambrose, LaCour-Little, and Sanders (2004); and Passmore, Sherlund, and Burgess (2004). Passmore, Sherlund, and Burgess (2004) find that of a 16 basis point jumbo-conforming spread, only 7 basis points are attributable to the GSE funding advantage.

spreads are determined simultaneously through the forces of supply and demand. For example, if the risk-adjusted spread between the interest rate on a loan and a benchmark funding rate were unusually wide, secondary market participants will buy more loans. As a result, if the primary market is competitive, primary market participants might extend more loans; if they do so, the equilibrium primary market interest rate might decline and the spread would then return to a more normal level.

However, the secondary market in conforming mortgages is far from a textbook competitive market. On one side of the market, the GSEs are almost the exclusive *purchasers* of conforming mortgages. Both their size and their government charters raise the possibility that they are not like other secondary market purchasers. On the other side of the market, a handful of large mortgage originators are the largest *sellers* of conforming mortgages. Thus, most GSE mortgage purchases are likely the outcome of a complicated dynamic strategic interaction among a handful of large entities.

The negotiated nature of GSE mortgage purchases suggests that there may be long and variable lags between GSE actions and any potential impacts on primary mortgage rates. In addition, the institutional structure of the conforming mortgage market suggests other reasons for such lags. First, average pricing prevails in conforming mortgage markets because credit risks are small relative to information, servicing, and marketing costs and because borrowers are relatively insensitive to small changes in mortgage rates.[2] Second, mortgage interest rates tend to be quot-

[2]For a discussion of average pricing in the mortgage market, including estimates of borrower

ed in eighths of 1 percentage point increments, so that small changes in the cost of funds may not be enough to warrant a change in mortgage rates. Finally, lenders might find it costly to adjust primary market rates to large swings in secondary market pricing that they view as transient.

If secondary market prices are not transmitted automatically into the primary mortgage market, GSE secondary market interventions may not be an effective policy tool for influencing mortgage rates. But even if the social benefit of the GSE portfolios is not evident during times when markets are functioning normally, purchases could have a particularly important effect during financial crises, when the GSEs may act affirmatively to calm market crises with larger-than-normal portfolio purchases. For example, during periods of financial market stress, investors demand larger than normal compensation for holding all risks, including the risks inherent in conforming mortgages. In such periods, GSEs might decide to buffer mortgage originators from financial market shocks, and thus limit the impact of such shocks on mortgage borrowers.

Again, the GSEs may not be special in performing this function. A purely private investor who believed mortgage spreads to be too large would behave like the GSEs and buy mortgages. What is unique about the GSEs is not that they buy assets when they expect a large return on equity, but that, unlike a purely private investor, GSEs can issue debt that other investors treat as implicitly insured by the government. Clearly, during a time of crisis, such debt might be better received in the markets than purely private debt and, ironically, financial crises

sensitivity to rate changes, see Hancock, Lehnert, Passmore, and Sherlund (forthcoming).

may allow GSE shareholders extraordinary profit opportunities. The key policy questions, however, are whether GSE actions actually influence primary mortgage rate spreads, and if so, how large the actual benefits to mortgage borrowers are.[3]

In addition, one can also question the necessity of the GSEs *using their portfolios* to influence mortgage rates. Mortgage originators can easily swap whole loans for GSE-guaranteed mortgage-backed securities.[4] These MBS carry a credit guarantee, and investors consider them to be safe and liquid investments. Thus, GSE mortgage securitization might be as important, or even more important, than portfolio purchases in influencing mortgage rates. Indeed, GSE portfolio purchases are likely to create a social benefit beyond that provided by MBS issuance only if GSE debt actually tapped a net new source of demand for mortgage assets, thereby lowering the GSEs' cost of funds. However, since the characteristics of GSE debt are already available in other debt instruments (or could be created from existing debt instruments), it seems difficult to identify these new investors.[5]

Based on the arguments presented above, GSE portfolio purchases and securitization activity are less likely to confer a social benefit if GSEs simply follow a profit-maximizing strategy of buying mortgages when spreads are unusually high unless mortgage rate spreads react rapidly to GSE purchases. Conversely, the GSEs could confer a social benefit if they actively managed the risk spreads paid

[3] Note that in this paper, we focus only on the gross benefits provided by the GSEs; we do not attempt to net out the estimated costs associated with these benefits.

[4] At the end of 2003, approximately $3.3 trillion in GSE-issued MBS were outstanding; of this, about $1.3 trillion were held in GSE portfolios.

[5] Indeed, many of the "newer" buyers of GSE debt—Asian buyers, in particular—appear to be simply substituting explicitly insured Treasury debt with implicitly insured GSE debt.

by conforming mortgage borrowers. In this view, the GSEs might be targeting mortgage rate spreads and heavily intervening in secondary mortgages whenever actual spreads deviate from a target, in an effort to promote social goals.

We analyze the effect of GSE secondary market activities (defined as purchases and securitization) on mortgage interest rate spreads (in both primary and secondary markets). If GSE secondary market activities have a social benefit, we would expect GSE activities to significantly affect primary market spreads. In addition, if the GSEs were affirmatively managing mortgage rate spreads, we would expect them to react quickly to news likely to affect mortgage spreads.

Our statistical approach directly estimates the effect of MBS issuance on primary and secondary mortgage rate spreads. In addition, we capture the effect of GSE debt issuance via our measures of portfolio purchases, which are almost exclusively financed via debt issuance.[6]

Our main finding is that GSE actions (whether portfolio purchases or gross MBS issuance) have negligible effects on primary or secondary mortgage spreads. That is, a sudden increase in GSE portfolio purchases or MBS issuance has essentially no long- or short-run effects on mortgage spreads. This finding is robust to alternative specifications, variable definitions, and identifying assumptions.

In addition, we characterize the time-series causality among mortgage spreads and GSE actions. Intuitively, this procedure measures whether GSE actions react

[6]Note that some GSE debt issuance is used to fund non-mortgage assets; however, debt used for these alternative purposes will likely have little impact on the mortgage market. As a result, debt issuance may be a poor proxy to measure the GSEs' impact on the mortgage market. We therefore use gross portfolio purchases to measure the GSEs' impact on the mortgage market.

to unexpected movements in spreads, whether spreads move in reaction to unexpected actions by the GSEs, or whether both happen together. Determining the causal relationship among time series is notoriously difficult. Nonetheless, the evidence supports the view that GSE purchases follow spreads. That is, unusually large portfolio purchases are not followed by unusual drops in mortgage interest rate spreads. Instead, the time-series evidence suggests that unusually large increases in spreads are followed by faster than normal portfolio growth.

While many studies have examined the general effect of GSEs on mortgage rates, only a few have attempted to estimate the specific effects of GSE portfolio and securitization activity on mortgage rates. A cointegration study by Naranjo and Toevs (2002) uses data covering 1986–98 and concludes that GSE securitization activity and portfolio purchases are associated with lower spreads between conforming mortgage interest rates and comparable Treasury interest rates.[7] Further, they conclude that total mortgage purchases are 30 percent more productive, dollar for dollar, at lowering the conforming-Treasury spread than is securitization activity. Similarly, Gonzalez-Rivera (2001) uses cointegration analysis, but her study of data from 1995–99 shows that larger portfolio purchases are associated with wider spreads. Further, she shows that about 84 percent of movements in the secondary market spread are passed through to the primary market spread.

There are several important differences between our study and those of Naranjo and Toevs and Gonzalez-Rivera. First, we use more recent data (1994–2003).

[7] They also find that portfolio purchases and securitization are associated with lower jumbo-Treasury spreads and higher jumbo-conforming spreads.

Second, we use gross GSE portfolio purchases, defined as whole loans, own MBS, and other MBS purchased, as a measure of the GSEs' portfolio activity, not just Fannie Mae's total mortgage purchases or net GSE portfolio purchases. Third, we estimate a full-information system of equations to avoid confounding the individual effects of portfolio purchases and securitization activity, and primary and secondary market spreads to swap yields. Finally, we recognize that any long-run cointegrating relationship does not necessarily specify a unique causal relationship.

We follow the earlier studies by using data on mortgage rate spreads to model the GSE portfolio management decision. However, this business decision is likely primarily influenced by the option-adjusted spread (OAS) on mortgages and GSE debt yields. The GSEs will find it more profitable to invest in mortgages when the OAS is unusually high or GSE debt yields are unusually low. Unfortunately, data on GSE data yields that correct for maturity are only available from 2000 on. In addition, we would ideally use high frequency data, with daily or weekly observations on spreads and GSE activities. However, data on GSE actions are available only at a monthly frequency. Thus, as is standard in this literature, we use monthly averages of raw mortgage rate spreads and monthly data on GSE actions and include controls for credit and prepayment risks in our analysis.

2 Theory

Mortgage interest rates (and their spreads) are affected by investors' expectations about mortgage risks (mainly credit and prepayment risks), financial market liquidity, and investors' expectations about the actions of all other participants, including the GSEs. At the same time, the GSEs are buying mortgages for their portfolios for many of these same reasons, and also because of the current level and expected future trajectory of mortgage rate spreads.

2.1 Structural Model

Consider a simple model of mortgage interest rate spreads (R_t) and GSE activities such as portfolio purchases (P_t):

(1) $$R_t = a_P P_t + a_Z Z_t + A_P P_{t-1} + A_R R_{t-1} + \varepsilon_t^R,$$

(2) $$P_t = b_R R_t + b_Z Z_t + B_P P_{t-1} + B_R R_{t-1} + \varepsilon_t^P.$$

Z_t represents (exogenous) variables that affect mortgage pricing, such as proxies for prepayment and credit risk.[8]

The innovations (or shocks) ε_t^R and ε_t^P can be induced by unexpected changes to liquidity, investor risk aversion, or uncertainty. These shocks are the primi-

[8] In our empirical work, instead of this stylized two-equation system, we use a richer *four*-equation system. For R_t, we use both primary and secondary market spreads; for P_t, we use both gross portfolio purchases and gross MBS issuance; and for Z_t, we use proxies for credit risk and prepayment risk. The interaction of these variables is necessarily complex; for simplicity we write the system in this form.

tive exogenous forces which "buffet the system and cause oscillations" [Bernanke (1986)]. In our empirical results we discuss the dynamic effects on R and P of one standard deviation movements in these shocks.

Equations (1)–(2) provide a simple statistical description of the equilibrium interaction of GSE actions, prices, and other observed and unobserved market forces. The theoretical connection among these variables could be quite complicated, in part because the equilibrium probably depends on how a small number of entities expect the others to behave. Equation (1) captures the stabilizing effects (if any) of GSE actions on spreads. Equation (2) captures the business decision of the GSEs; in particular, how their portfolio managers react to movements in spreads.

In this representation, a_P is the contemporaneous effect of this period's purchases on this period's spreads and A_P is the direct effect of last period's purchases on this period's spreads.[9] In the same way, b_R captures the contemporaneous effect of spreads on purchases and B_P captures the lagged direct effect.

Any model in which GSE purchases pushed down mortgage spreads in the same period would imply that $a_P < 0$. In the same way, any model in which wider spreads increased GSE purchases in the same period would imply that $b_R > 0$. These are only the very short-run effects, though. The long-run effect of GSE purchases on spreads is the sum of the contemporaneous direct effect (a_P) and the lagged direct effect (A_P); in addition, GSE purchases will affect spreads through

[9] For clarity, we have here excluded more than one lagged value from our equations, although in the empirical work we allow for an arbitrary number of lags. As we discuss in section 4.1, we use two lags of the endogenous variables and one lag of the exogenous variables.

the indirect effects of equation (2). Because these direct and indirect effects can quickly become complicated, the standard method of describing them is via impulse response functions. This is just the dynamic response of each of the variables in the system to a standard shock to either ε_t^P (to capture the effect of an unexpected increase in purchases) or ε_t^R (to capture the effect of an unexpected increase in spreads).

Granger causality tests and other statistical techniques examine the effects of lagged variables on current variables, that is, whether $A_P = 0$ or $B_R = 0$. Based on these tests and our sensitivity analysis, as we discuss below, we conclude that the statistical evidence supports the view that GSE actions react to interest rate movements rather than the other way around.

2.2 Reduced-Form Estimates

Without additional assumptions, we cannot uniquely identify *both* the contemporaneous effect of purchases on spreads, a_P, *and* the contemporaneous effect of spreads on purchases, b_R. To estimate b_R we must restrict a_P, either by forcing it to be zero or by setting it to some value suggested by other data or theory. In the same way, to estimate a_P we must restrict b_R.

In this simplified system, the identification problem can be seen by rewriting the system of equations (1)–(2) with the contemporaneous terms on the left-hand side:

$$R_t - a_P P_t = a_Z Z_t + A_P P_{t-1} + A_R R_{t-1} + \varepsilon_t^R,$$
$$P_t - b_R R_t = b_Z Z_t + B_P P_{t-1} + B_R R_{t-1} + \varepsilon_t^P.$$

Using matrix notation, this can be written as:

$$\begin{bmatrix} 1 & -a_P \\ -b_R & 1 \end{bmatrix} \begin{pmatrix} R_t \\ P_t \end{pmatrix} = \begin{bmatrix} A_R & A_P \\ B_R & B_P \end{bmatrix} \begin{pmatrix} R_{t-1} \\ P_{t-1} \end{pmatrix} + \begin{bmatrix} A_Z \\ B_Z \end{bmatrix} Z_t + \begin{pmatrix} \varepsilon_t^R \\ \varepsilon_t^P \end{pmatrix}.$$

Define X_t as the vector of variables $(R_t, P_t)'$ and ε_t as the vector of structural innovations $(\varepsilon_t^R, \varepsilon_t^P)'$. Then we can rewrite the system as:

(3) $$\Phi_0 X_t = \Phi_1 X_{t-1} + \Phi_Z Z_t + \varepsilon_t.$$

The innovations are assumed to have a variance-covariance matrix of Λ. Because the shocks are defined as pure innovations to the structural system, it is standard practice to assume that they are uncorrelated. Thus, we assume that Λ is a diagonal matrix, i.e., its off-diagonal elements are all equal to zero.

We cannot estimate the parameters of the structural model directly. Instead, we estimate the parameters from an unrestricted reduced-form model and, under a set of identifying assumptions, compute the structural parameters from the reduced-form parameters. More precisely, we estimate the coefficients from the model:

$$
\begin{aligned}
X_t &= \Phi_0^{-1}\Phi_1 X_{t-1} + \Phi_0^{-1}\Phi_Z Z_t + \Phi_0^{-1}\varepsilon_t \\
&\equiv \Gamma X_{t-1} + \Gamma_Z Z_t + u_t.
\end{aligned} \tag{4}
$$

Thus, Γ is a mixture of the structural coefficients in Φ_0 and Φ_1. Further, the reduced-form errors, u_t, are a linear combination of the structural shocks, ε_t. Thus, even though the variance-covariance matrix of ε_t is diagonal, the variance-covariance matrix of u_t will be, in general, non-diagonal. In fact, the variance-covariance matrix of the reduced-form errors is:

$$
E\left[uu'\right] = \Phi_0^{-1}\Lambda\Phi_0^{-1\prime} \equiv \Sigma. \tag{5}
$$

Identifying restrictions are often used to compute the elements of Φ_0, Φ_1, and Λ from estimates of Γ and Σ. If there are n endogenous variables in the system, Γ contains n^2 unique entries and Σ, which is symmetric, contains $n(n+1)/2$ unique entries. Thus, we can identify $n^2 + n(n+1)/2$ structural parameters. However, Φ_0 contains $n(n-1)$ unique entries (its diagonal elements are ones), Φ_1 contains n^2 unique entries, and Λ, which is diagonal, contains n unique entries—for a total of $2n^2$ structural parameters. Thus, identification requires $n(n-1)/2$ additional restrictions on the structural parameters. The most common type of identifying restriction is that Φ_0 be triangular (that is, all the entries above [or below] the diagonal are all equal to zero).

Assuming that Φ_0 is triangular is tantamount to assuming *either* that $b_R = 0$ *or* that $a_P = 0$. Under the assumption that $a_P = 0$, contemporaneous shocks to purchases, ε_t^P, do not affect spreads, R_t, in period t. However, contemporaneous shocks to spreads, ε_t^R, may affect purchases, P_t, in period t.[10] In other words, under this assumption, GSE actions may respond to all information in a given period, but spreads respond with a slight lag.

Under the alternative assumption that $b_R = 0$, contemporaneous shocks to spreads, ε_t^R, do not affect purchases, P_t, in period t. However, contemporaneous shocks to purchases, ε_t^P, may affect spreads, R_t, in period t. In other words, under this assumption, spreads may react to all contemporaneous information while GSE activities react with a slight lag.

The latter identifying assumption is consistent with the notion that spreads are determined continuously over time in financial markets, while GSE activities are the result of slower-moving business decisions. However, we also consider several different identifying assumptions as robustness checks on our preferred, baseline specification.

3 Data

We obtained consistent data on GSE portfolio purchases, securitization volume, and mortgage interest rate spreads at a monthly frequency for the ten-year period 1994–2003, for 120 total observations. In addition, our dataset contains covariates

[10]Because no restrictions are placed on Φ_1, shocks to either purchases or spreads in period t can affect both purchases and spreads in period $t + 1$.

designed to control for credit and prepayment risk.

Our measure of GSE portfolio purchases is the sum of Fannie Mae and Freddie Mac's gross retained portfolio purchases of mortgage assets, including whole loans, own MBS, and other MBS.[11] Our measure of securitization volume is the sum of Fannie Mae and Freddie Mac's gross issuance of MBS. These data are available on the GSEs' monthly summary reports.

As part of our robustness analysis, we normalize portfolio purchases and gross MBS issuance by measures of the size of the residential mortgage market. We follow other studies in using the monthly total volume of *new* residential mortgages originated (both purchase and refinance) as our measure of total market size. We estimate this measure with the time series of mortgage originations as reported under the Home Mortgage Disclosure Act (HMDA).

We use both primary and secondary market interest rates to compute our measures of mortgage rate spreads. The primary market mortgage rate is defined as the monthly average interest rate on new 30-year fixed-rate mortgages, from Freddie Mac's primary mortgage market survey. Secondary market mortgage rates are defined as the monthly average current coupons on Fannie Mae and Freddie Mac 30-year MBS.[12]

We do not use the levels of these primary and secondary market mortgage rates in our analysis; instead, as is common practice, we use the spread to a relevant

[11]Measuring the effects of GSE portfolio purchases is difficult because there can be long lags between when a GSE commits to a mortgage purchase and when the purchase is brought onto the GSEs' books. However, the GSEs do not release enough data publicly to attempt to adjust for these lags.

[12]The use of month-end data did not materially alter our results.

risk-free rate. We have experimented with a variety of different measures of the risk-free rate. However, in our analysis here we report results using the spreads to a simple average of the 5-year and 10-year Treasury rates. Our results are almost completely unchanged by the choice of interest rate index. As shown in table 1, changes in GSE debt yields, Treasury yields, and swap yields are very highly correlated.[13]

The primary risks priced into mortgage rates (but not risk-free rates) are credit risk (the risk of default) and prepayment risk (the risk of refinancing). As a proxy for credit risk, we use the realized serious delinquency rate on conforming mortgages owned by the GSEs.[14] We proxy prepayment risk with a measure of the incentive to refinance. In particular, we use the mortgage coupon gap—the spread between the weighted average coupon on existing securitized 30-year mortgages and the 30-year fixed-rate mortgage rate.

Descriptive statistics for key series are provided in table 2. Figure 1 plots the time series of GSE portfolio purchases, GSE securitization volume, mortgage market spreads, and mortgage delinquencies and the coupon gap. Note that the financial market crisis of October 1998 was associated with a sharp widening of spreads; as shown in the figure, primary market spreads rose about 70 basis points. Serious mortgage delinquencies have a fairly narrow range, between 45 and 62 basis points; the coupon gap has varied substantially from -102 to $+168$ basis points.

[13] We also used a simple average of 5-year and 10-year swaps and found no significant differences in our results.

[14] "Serious delinquencies" are defined as mortgages 90 or more days past due or in foreclosure.

4 VAR Results

In this section we examine the relationship between GSE activities and mortgage market spreads using VAR techniques. We compute the dynamic responses of mortgage rate spreads to an unexpected shock to GSE activities under our baseline identifying assumption. Our primary specification is in first-differences; we also report a full set of results under an alternative specification in normalized levels. As a robustness check on these results, we examine the cumulative impulse responses under a variety of alternative identifying assumptions. We also show that GSE actions during the liquidity crisis of 1998 were not extraordinary; further, had GSEs done nothing during this period, primary and secondary market spreads would have evolved in about the same way.

4.1 Estimation

We estimate the parameters of an unrestricted reduced-form VAR as described in section 2.2. Rather than use the levels of the variables, we estimated the model using first-differences of the variables. (We use the logs of portfolio purchases and securitization activity.) As shown in table 3 we find evidence that some of the variables might have unit roots in their levels; however, each series is stationary in first differences.[15]

We determined the optimal number of lags to include in our specification using

[15] We have also estimated this VAR under a wide variety of alternative variable definitions, including a specification with the *level* of spreads and the *growth* of GSE activity. Our results were in line with those reported here: GSE actions, especially portfolio purchases, have very little effect on spreads.

the Akaike Information Criterion (AIC). We found that 2 lags of the endogenous variables (GSE actions and spreads) and 1 lag of the exogenous variables (prepayment and credit risk proxies) minimized the criterion.

We are interested in testing the ability of GSEs to stabilize mortgage markets as well as to lower mortgage spreads in the long run. However, these two goals are not necessarily equivalent. The GSEs might be able to dramatically affect spreads in the short run, but then see these effects undone over time, leaving spreads unchanged in the long run. Conversely, the GSEs might be unable to affect spreads very much in a given month, but might be able to cumulate their effects over time, producing a significant long-run effect without large effects in any given period.

For our baseline model, we report a full set of impulse response functions. For the alternative specifications and identifying assumptions, we summarize the short- and long-run effects of GSEs on rates with two statistics: The cumulative impulse response after 24 months and the largest cumulative effect (and when that effect occurs).

4.2 Results Under Baseline Identification

We impose a triangular (Wold) representation on our system of equations to examine the impulse response functions. (See section 2 for a discussion of this procedure.) This requires *assuming* that certain variables in our system do not respond contemporaneously to shocks in other equations. However, we do not restrict any of the lagged effects, so all endogenous variables may react to any shock in the previous period. (As we discussed, we do not estimate reaction functions for credit and prepayment risk, but rather take these two variables as exogenous to our system.)

In our baseline identification, we assume that shocks to GSE activities have no contemporaneous effect on mortgage market spreads. That is, we assume that the ordering of innovations in the Cholesky decomposition is: $[\varepsilon_{r^s-r}, \varepsilon_{r^p-r}, \varepsilon_s, \varepsilon_p]$. Later, we compute impulse response functions under several alternatives to this baseline assumption.

Intuitively, our ordering of contemporaneous responses assumes that the GSEs observe all available information in a period before reacting. Our ordering thus perforce assumes that shocks to secondary market spreads occur during a period and are not affected by GSE actions during the rest of the period. Primary market spreads react to secondary market spreads, but not to GSE actions. Of the GSE actions, gross MBS issuance reacts to spreads, and portfolio purchase volume reacts to all contemporaneous variables.

We consider several alternatives to our baseline ordering, including several in which spreads react to GSE actions. Under these alternatives, though, GSE actions have less of a long-run effect on mortgage rate spreads.

With an assumption about the contemporaneous effects of shocks in our system, we can estimate the effect of orthogonalized one standard deviation shocks of each innovation on each of our endogenous variables. In other words, we can estimate, for example, the dynamic response of primary mortgage market spreads to a one-time standardized shock to the portfolio purchase equation. A complete set of these impulse response functions is shown in figure 2. Each panel shows the effects of one standard deviation shocks of each innovation on a given variable.

Effect of Shock to Secondary Market Spreads (ε_{r^s-r}) Cumulating the effects across all months, a one standard deviation shock to the secondary market spread innovation (about 8 basis points) ultimately leads to a 9.9 basis point increase in the secondary market spread, an 11 basis point increase in the primary market spread, a 7.3 percent increase in securitization, and a 14.1 percent increase in purchases. The largest cumulative effects have occurred within three or four months of the shock.

Effect of Shock to Primary Market Spreads (ε_{r^p-r}) In the same way, a one standard deviation shock to the primary market spread innovation (about 4 basis points) ultimately leads to a 2.5 basis point increase in the primary market spread, a 1.1 basis point decrease in the secondary market spread, a 3.9 percent increase in securitization, and a 0.2 percent increase in purchases. Here, the largest cumulative effects take up to five months to occur.

Effect of Shock to GSE Actions (ε_s and ε_p) Turning to the effects of shocks to the securitization and portfolio innovations, we find that a one standard deviation shock to the securitization innovation (about 16 percent) ultimately leads to a 14.6 percent increase in securitization, an 8.7 percent increase in purchases, a 2.1 basis point decline in the secondary market spread, and a 1.7 basis point decline in the primary market spread—with the largest cumulative effects occurring within five months of the shock.

A one standard deviation shock to the portfolio purchase innovation (about 26 percent) ultimately leads to a 17 percent increase in purchases, a 3.8 percent increase in securitization, a 0.5 basis point decline in the secondary market spread, and a 0.2 basis point decline in the primary market spread.[16] Here, the largest cumulative effects have taken place within four months of the shock.

Thus, based on our impulse response analysis, we estimate that if the GSEs unexpectedly increase their portfolio purchases by $10 billion (or 12.7 percent of the 2003 average), the secondary market spread would decline about 0.3 basis points and the primary market spread would decline about 0.1 basis points over the long-run. But if the GSEs instead unexpectedly increased their securitization activity by $10 billion (or 6.3 percent of the 2003 average), we estimate that the secondary market spread would decline about 0.8 basis points and the primary market spread would decline about 0.7 basis points. These results suggest that GSE portfolio purchases have economically and statistically negligible effects on mortgage market spreads, even in the long run. Further, portfolio purchases are not more effective at reducing mortgage market spreads than securitization activities.

Variance Decomposition Figure 3 shows variance decomposition proportions for the key data series. Variance decompositions indicate how much of the forecast error in a series is due to a shock to its own innovation and how much is due to shocks to other innovations. As shown, GSE activities account for very little of the

[16]The average (absolute) month-to-month change in GSE portfolio purchases is 24 percent. Moreover, such a shock amounts to less than 0.6 percent of the GSEs' combined retained portfolios.

forecast errors of mortgage market spreads. Secondary market spreads, however, account for a sizable proportion of the forecast errors of primary market spreads and portfolio purchase volume.

4.3 The 1998 Liquidity Crisis

In a dramatic example of the dynamics of the system, from August 1998 to October 1998, secondary market spreads widened about 69 basis points as a result of a liquidity shock. During the same time, primary market spreads widened 78 basis points, securitization volume decreased 5 percent, and portfolio purchases jumped 76 percent.

Obviously, during this period, spreads and purchases moved much more than during normal periods. As a test of our model's ability to explain GSE behavior and the evolution of spreads, we initialized the model with the secondary market spread changes in September and October and allowed the system to evolve endogenously without any other information. As shown by the first panel of figure 4, we forced secondary market spreads to increase about 30 basis points in September and 39 basis points in October. We then allowed secondary market spreads to evolve as predicted by the model. As shown, the model predicted that the changes in spreads would gradually decline to zero. In reality, spreads jumped around our model's prediction in reaction to incoming data (such as prepayment and credit risk information). Primary market spreads, the next panel, show about the same dynamics.

Turning to GSE actions, the next two panels show that our model is successful in predicting purchase volume in the peak crisis period, September through December 1998. Our model cannot explain the big drop in purchases in January 1999, or the offsetting rise in February 1999. However, in the long run these forecast errors roughly cancel out, leaving the predicted net change in purchases over the entire period close to the actual change. Our model also does a decent job of predicting securitization volume through this episode. Actual MBS issuance was much more volatile than predicted by our model, although, again, the forecast errors net out to about zero.

Thus, the GSEs' portfolio purchases during this period of financial market stress can be explained almost completely by their historical pattern of buying mortgages when spreads are wide. That is, there was nothing special about the GSEs' actions during this period of financial market stress.

However, even though GSE actions during the crisis were roughly consistent with their behavior at other times, it could be that the magnitudes in this particular episode were large enough to mitigate the effects on spreads. To test this theory, we computed the changes in spreads that would have occurred had the GSEs not changed their portfolio behavior during the crisis. In other words, we force portfolio purchases to be constant at $30.5 billion through the episode.

In figure 4, the difference between this counterfactual experiment (the dotted line) and the model's prediction (the dashed line) is our estimate of the effect of GSE portfolio purchases on the mortgage market during the crisis period. As shown, the GSEs' portfolio purchases appear to have had little effect on either primary or secondary mortgage market spreads. However, there was a substantial effect on securitization activity.

4.4 Results Under Alternative Identifying Assumptions

With four endogenous variables in our system there are potentially four factorial, or 24, different triangular representations of the system. The previous section reported results in detail under our baseline identification assumptions. In this section, we summarize results under several alternative representations. We focus on two classes of alternatives: first, reasonable reorderings of our baseline specification (VAR) and, second, orderings suggested by the efficient markets hypothesis (EMH).

For each alternative ordering, we summarize the long-run response of variables to shocks with the cumulative impulse response functions shown in table 4. We also summarize the short-run response of variables to shocks by reporting the largest cumulative response in table 5. The column labeled VAR 1 in the table reports the results under our baseline specification, which we have already discussed. From a policy perspective, the most interesting results are the effects of GSE actions on mortgage market spreads. As shown, these effects are negligible and do not vary significantly under the different identifying assumptions.

4.4.1 Reorderings of Baseline Specification

It could be argued that spreads react to all information available in a given month, while GSE actions are somewhat constrained by prior agreements with originators. In other words, mortgage spreads react continuously to information flow, while portfolio purchases and MBS issuance have more inertia.

The alternative representations, labeled VAR 2 and VAR 3, assume some degree of inertia in GSE actions. In VAR 2, the primary market spread reacts contemporaneously to shocks to GSE actions and the secondary market spread. GSE actions, in turn, react contemporaneously only to shocks to the secondary market spread. In VAR 3, primary and secondary market spreads react contemporaneously to shocks to GSE actions. GSE actions, in turn, do not react contemporaneously to shocks to spreads.

The first three columns of tables 4–5 summarize the results under the baseline and alternative orderings. As shown, the results are not very different under the alternatives than under the baseline ordering. In particular, shocks to GSE actions continue to have small effects on mortgage market spreads.

4.4.2 Efficient Markets Hypothesis

The efficient markets hypothesis (EMH) maintains that an asset's price ought to reflect all relevant available information about that asset. The EMH can have strong implications for identification in VARs (see Sarno and Thornton, 2004). Our system contains two endogenous asset price variables: the secondary market spread and the primary market spread. Under a triangular representation, these two variables cannot react to the same set of shocks, so we must order them by their relative inertia. Primary mortgage market interest rates (and thus their spreads) are relatively sticky for the reasons discussed earlier. In addition, our measure of the primary market rate is Freddie Mac's survey of lenders, which is conducted only weekly.

In table 4, the column labeled EMH 1 reports results under a strong version of the EMH: GSE actions do not respond to shocks to any asset price equations. The columns labeled EMH 2 and EMH 3 report results under slightly relaxed versions of the EMH. In EMH 2, GSE actions respond to primary market shocks. In EMH 3, GSE actions react to both primary and secondary market shocks. As shown in the tables, these alternative orderings do not significantly alter our baseline results.

4.5 Results Under a Levels Specification

The results reported in section 4.2 were based on a model estimated using the first-difference of mortgage spreads and the percent changes in GSE activity. We adopted this as our primary specification because GSE activity is clearly non-stationary and GSE spreads, while probably stationary, are highly persistent. Another approach is to normalize GSE actions by some measure of the size of the market and estimate the model using normalized GSE actions and the level of spreads. Note that both spreads and normalized GSE actions are fairly persistent, so these results may be contaminated by a common trend in both sets of variables.

As we discussed in section 3, we normalize GSE portfolio purchases and gross MBS issuance by estimates of mortgage originations derived from the HMDA reports. The normalized time series are shown in figure 5.

We follow the same estimation procedure as before. For completeness, we report a full set of impulse response functions in figure 6. Note the extreme persistence of shocks. In many cases the shocks continue to affect variables five years after the initial period. The top two panels of the figure show the response of spreads to standardized shocks to other variables, including GSE actions. As before, shocks to portfolio purchases have no statistically significant effect on mortgage rate spreads. Thus, our main results are unchanged.

4.6 Granger Causality Results

F-test statistics from bivariate Granger causality tests among all variables in the system are reported in table 6. The null hypothesis in these tests is that the variable in the table row does not Granger-cause the variable in the table column. For convenience, if we can reject the null we say that the row Granger-causes the column (as opposed to saying that the row does not "not Granger cause" the column). From table 6 we see that mortgage market spreads Granger-cause portfolio purchases and securitization volume, but not the converse. Also note that securitization volume and portfolio purchases Granger-cause each other. These results are summarized in figure 7.

5 Cointegration Analysis

Other studies, most notably Naranjo and Toevs (2002), have used cointegration techniques to study the statistical relationship between GSE actions and mortgage market spreads. In effect, these techniques require the assumption that all variables in the system contain a common trend. This assumption is reasonable for variables such as the level of gross MBS issuance and the level of portfolio purchases. However, this assumption is economically less reasonable for variables such as mortgage rate spreads and the relative level of GSE actions. Nonetheless, we proceed with the cointegration analysis for comparison with earlier studies.

In this section we once again examine the impulse responses of variables in the system under the assumption that all variables are cointegrated. In place of our VAR, we estimate the parameters from a vector error-correction model, or VECM. As in the VAR analysis, we use a standard set of identifying restrictions.

There are several economic and statistical reasons to doubt the estimates produced under this specification. First, the estimated cointegrating relationship is primarily between securitization and portfolio purchases; mortgage market spreads, the key variables of policy concern, are statistically insignificant elements of cointegrating vector. Second, it is statistically difficult to distinguish between unit root and near unit root series, so it is possible that the estimated long-run relationship is spurious.[17] Third, we cannot establish that each of our endogenous variables is integrated of the same order. Last, it is generally accepted that interest-rate spreads cannot in principle be integrated of order one. That we cannot statistically reject this hypothesis is the result of using cointegration techniques over short time spans. We therefore discount the results in this section and emphasize our VAR results in section 4.

[17] If the system is truly *not* cointegrated, using cointegration techniques can produce spurious results. If the system is truly cointegrated, however, using a difference-stationary VAR produces correct, albeit possibly inefficient, results.

5.1 VECM Results

For the system defined in equation (3) to be cointegrated, a necessary condition is that each component of X_t be integrated of the same order (for example, each component of X_t has a unit root and is stationary in first differences). Additionally, there must be at least one linear combination of X_t that is stationary. As shown in table 3, portfolio purchases might not contain a unit root. This is similar to the result reported by Gonzalez-Rivera (2001).

To examine the second necessary condition for cointegration, we use Johansen's (1988, 1991) maximum likelihood procedures to estimate any long-run cointegrating relationships in equation 3. Johansen's trace and max statistics suggest that our system of equations has multiple cointegrating relationships. The first relationship can be written as:

$$\text{(6)} \quad \widehat{\varepsilon}_t \; = \; 1.1882 + 0.0188(r_t^p - r_t) - 0.0050(r_t^s - r_t) - 1.8534 s_t + p_t.$$

Here, $\widehat{\varepsilon}_t$ denotes the deviations from the estimated long-run relationship. Note that we have normalized with respect to GSE portfolio purchases, so p_t has a unit coefficient in this representation.

Figure 8 shows actual purchases, the equilibrium level of purchases (that is, the level consistent with the long-run relation given the actual values for other variables in equation 6), and the deviations from the long-run path. Purchases do track their long-run levels, but the deviations are frequent and exhibit serial correlation for extended periods, reaffirming the potential problems with using cointegration techniques in such a setting.

Tables 7–8 summarize the impulse responses for each endogenous variable to shocks to each structural innovation for three different orderings of innovations. The results, once again, are similar to those from our baseline VAR specification: GSE portfolio purchases have negligible effects on mortgage market spreads.

5.2 Comparison With Other Studies

For comparability, we also estimate the Naranjo and Toevs (2002) and Gonzalez-Rivera (2001) specifications using our dataset. We find that under Naranjo and Toevs's specification, unanticipated shocks to GSE portfolio purchases again have no meaningful effect on mortgage market spreads. Under Gonzalez-Rivera's specification, unanticipated shocks to GSE portfolio purchases increase secondary market mortgage spreads slightly. However, as we discussed, these results are obtained under strong and unrealistic assumptions.

Moreover, Naranjo and Toevs normalize portfolio purchases and securitization by the size of the mortgage market to relate GSE activity to the primary mortgage spread. We use an estimate of mortgage originations derived from HMDA data as the normalization. As shown in tables 7–8, an unanticipated increase in the GSEs' portfolio purchase share of the market of about 5 percent has little effect on the primary market spread. Conversely, an unanticipated increase in the primary market spread of about 9 basis points leads to an increase in the GSE portfolio purchase share of the market of slightly over 1 percent. Similarly, an unanticipated 5.5 percent increase in the GSEs securitization share of mortgage originations leads to

1.8 basis point increase in the primary market spread, and an unanticipated 9 basis point increase in the primary market spread increases the GSEs' securitization share of mortgage originations nearly 2 percent. Note that under this specification, we can find no evidence that GSE activities decrease mortgage market spreads or that portfolio purchases are in any sense better than securitization activity.

Gonzalez-Rivera (2001) relates the raw level of (net) portfolio purchases to the secondary market spread. Under this specification, an unexpected increase in GSE portfolio purchases of $11 billion decreases the secondary market spread nearly 3 basis points. An unexpected 8 basis point increase in the secondary mortgage market spread increases GSE portfolio purchases nearly $8 billion.

6 Conclusion

This paper examines the statistical evidence of a connection between GSE secondary market actions and the interest rates paid by mortgage borrowers. While GSE portfolio purchases benefit GSE shareholders directly, the purchases must lower the mortgage rate paid by the homeowner in order to have a wider social benefit.

We find, however, that portfolio purchases has economically and statistically negligible effects on mortgage rates. Further, portfolio purchases are not any more effective at decreasing spreads than securitization volume. Our results were robust to several alternative identifying assumptions, including those suggested by the efficient markets hypothesis.

Earlier studies by Naranjo and Toevs (2002) and Gonzalez-Rivera (2001) found that GSE actions did significantly affect mortgage spreads. We repeated the cointegration analyses used in those studies with our more recent data set and found, again, that GSE actions have only negligible effects on mortgage spreads.

Further, we studied the 1998 liquidity crisis and found that GSE actions generally followed the predictions of the model. Had GSE actions remained unchanged through this episode, we estimate that mortgage spreads paid by borrowers would have been essentially unchanged. Thus, the GSEs do not appear to have played a significant role in managing mortgage market risks through the 1998 crisis.

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TABLE 1: Correlations Among Interest Rates

10-year	GSE Debt	Treasury	Swaps
GSE Debt	1.0000		
Treasury	0.9557	1.0000	
Swaps	0.9915	0.9688	1.0000
5-year	**GSE Debt**	**Treasury**	**Swaps**
GSE Debt	1.0000		
Treasury	0.9720	1.0000	
Swaps	0.9960	0.9756	1.0000

NOTE. Table gives correlation coefficients among *monthly differences in yields* on comparable debt instruments. Data are monthly averages, Jan. 2000 through Dec. 2003.

TABLE 2: Descriptive Statistics

Variable	Symbol	Mean	Median	Std. Dev.	Min	Max
Securitization Volume ($bn)	s_t	54.70	35.11	47.70	7.47	204.28
Portfolio Purchase Volume ($bn)	p_t	28.44	19.84	26.82	3.45	148.67
Primary Market Spread (bps)	$r_t^p - r_t$	181.05	173.69	39.20	122.95	268.52
Secondary Market Spread (bps)	$r_t^s - r_t$	144.81	143.70	28.21	102.68	203.56
Mortgage Coupon Gap (bps)	pr_t	45.12	55.92	61.26	-101.92	168.45
Mortgage Delinquencies (bps)	cr_t	53.27	54.00	5.10	45.00	62.00

NOTE. Statistics are for 120 monthly observations running from January 1994 through December 2003.

TABLE 3: Augmented Dickey-Fuller Unit Root Tests

		Levels		First Differences	
Variable		Intercept	Intercept+Trend	Intercept	Intercept+Trend
Securitization Volume	s_t	-1.12	-3.21	$-4.70^{\star\star}$	$-4.61^{\star\star}$
Portfolio Purchase Volume	p_t	-1.60	$-3.52^{\star}$	$-7.00^{\star\star}$	$-6.96^{\star\star}$
Primary Market Spread	$r_t^p - r_t$	-1.67	$-3.87^{\star}$	$-5.75^{\star\star}$	$-5.72^{\star\star}$
Secondary Market Spread	$r_t^s - r_t$	-2.22	$-3.70^{\star}$	$-6.37^{\star\star}$	$-6.35^{\star\star}$
Mortgage Coupon Gap	pr_t	-2.67	-2.78	$-5.75^{\star\star}$	$-5.68^{\star\star}$
Mortgage Delinquencies	cr_t	-1.74	-1.73	$-3.88^{\star\star}$	$-3.86^{\star\star}$

NOTE. H_0: Unit root. *and **denote statistical significance at the 5- and 1-percent levels, respectively.

TABLE 4: Cumulative Long-Run Effects

		Baseline Vector Auto Regression			Efficient Markets Hypothesis		
Shock to	Effect on	VAR 1	VAR 2	VAR 3	EMH 1	EMH 2	EMH 3
				Percent			
ε_s	s	$14.6^\star$	$14.8^\star$	$15.0^\star$	$15.0^\star$	$14.6^\star$	$14.6^\star$
ε_p	s	$3.8^\star$	$3.7^\star$	$5.3^\star$	$5.3^\star$	$3.7^\star$	$3.8^\star$
ε_{r^s-r}	s	$7.3^\star$	$7.3^\star$	$5.8^\star$	-0.7	-0.7	-0.8
ε_{r^p-r}	s	3.9	3.2	3.2	$6.5^\star$	$8.3^\star$	$8.3^\star$
ε_s	p	$8.7^\star$	$8.7^\star$	$9.1^\star$	$9.1^\star$	$8.5^\star$	$8.7^\star$
ε_p	p	$17.0^\star$	$17.0^\star$	$20.0^\star$	$20.0^\star$	$17.6^\star$	$17.0^\star$
ε_{r^s-r}	p	$14.1^\star$	$14.1^\star$	$9.2^\star$	3.4	3.4	5.2
ε_{r^p-r}	p	0.2	0.2	0.2	$8.5^\star$	$13.1^\star$	$13.1^\star$
				Basis Points			
ε_s	r^s-r	-2.1	-2.2	-1.9	-1.9	-2.3	-2.1
ε_p	r^s-r	-0.5	-0.5	2.0	2.0	0.0	-0.5
ε_{r^s-r}	r^s-r	$9.9^\star$	$9.9^\star$	$9.7^\star$	$4.7^\star$	$4.7^\star$	$4.8^\star$
ε_{r^p-r}	r^s-r	-1.1	-1.0	-1.0	$8.6^\star$	$8.7^\star$	$8.7^\star$
ε_s	r^p-r	-1.7	-1.6	-1.3	-1.3	-1.8	-1.7
ε_p	r^p-r	-0.2	-0.3	2.4	2.4	-0.0	-0.2
ε_{r^s-r}	r^p-r	$11.0^\star$	$11.0^\star$	$10.8^\star$	1.8	1.8	1.9
ε_{r^p-r}	r^p-r	2.5	2.6	2.6	$10.9^\star$	$11.1^\star$	$11.1^\star$

NOTE. The table gives the long-run effects of shocks to the indicated innovations on the indicated variables under various assumptions about causality. The columns refer to different orderings of innovations, where VAR 1 is our baseline assumption (see the text for details). VAR 1: $[\varepsilon_{r^s-r}, \varepsilon_{r^p-r}, \varepsilon_s, \varepsilon_p]$. VAR 2: $[\varepsilon_{r^s-r}, \varepsilon_s, \varepsilon_p, \varepsilon_{r^p-r}]$. VAR 3: $[\varepsilon_s, \varepsilon_p, \varepsilon_{r^s-r}, \varepsilon_{r^p-r}]$. EMH 1: $[\varepsilon_s, \varepsilon_p, \varepsilon_{r^p-r}, \varepsilon_{r^s-r}]$. EMH 2: $[\varepsilon_{r^p-r}, \varepsilon_s, \varepsilon_p, \varepsilon_{r^s-r}]$. EMH 3: $[\varepsilon_{r^p-r}, \varepsilon_{r^s-r}, \varepsilon_s, \varepsilon_p]$. *denotes statistical significance at the 5-percent level.

TABLE 5: Maximal Cumulative Effects

		Baseline Vector Auto Regression			Efficient Markets Hypothesis		
Shock to	Effect on	VAR 1	VAR 2	VAR 3	EMH 1	EMH 2	EMH 3
					Percent		
ε_s	s	$16.2_0^\star$	$16.2_0^\star$	$16.3_0^\star$	$16.3_0^\star$	$16.2_0^\star$	$16.2_0^\star$
ε_p	s	$5.5_2^\star$	$5.4_2^\star$	$6.6_2^\star$	$6.6_2^\star$	$5.3_2^\star$	$5.5_2^\star$
ε_{r^s-r}	s	$7.8_4^\star$	$7.8_4^\star$	$6.2_4^\star$	-2.0_2	-2.0_2	-1.9_2
ε_{r^p-r}	s	4.6_2	3.9_2	3.9_2	$7.1_4^\star$	$8.8_4^\star$	$8.8_4^\star$
ε_s	p	$11.1_1^\star$	$11.1_1^\star$	$11.4_1^\star$	$11.4_1^\star$	$11.0_1^\star$	$11.1_1^\star$
ε_p	p	$26.1_0^\star$	$26.1_0^\star$	$27.0_0^\star$	$27.0_0^\star$	$26.3_0^\star$	$26.1_0^\star$
ε_{r^s-r}	p	$15.2_3^\star$	$15.2_3^\star$	$9.9_2^\star$	3.7_5	3.7_5	5.4_5
ε_{r^p-r}	p	0.9_3	0.9_3	0.9_3	$9.4_3^\star$	$14.3_3^\star$	$14.3_3^\star$
					Basis Points		
ε_s	r^s-r	-2.3_5	-2.3_5	-2.0_5	-2.0_5	-2.4_5	-2.3_5
ε_p	r^s-r	-0.7_4	-0.7_4	$2.6_2^\star$	$2.6_2^\star$	0.5_2	-0.7_4
ε_{r^s-r}	r^s-r	$10.8_2^\star$	$10.8_2^\star$	$10.5_2^\star$	$4.9_4^\star$	$4.9_4^\star$	$4.9_4^\star$
ε_{r^p-r}	r^s-r	-1.1_5	-1.0_5	-1.0_5	$9.5_2^\star$	$9.7_2^\star$	$9.7_2^\star$
ε_s	r^p-r	-1.9_5	-1.7_5	-1.4_5	-1.4_5	-1.9_5	-1.9_5
ε_p	r^p-r	-0.3_4	0.5_1	$3.3_1^\star$	$3.3_1^\star$	0.7_1	0.6_1
ε_{r^s-r}	r^p-r	$11.8_2^\star$	$11.8_2^\star$	$11.5_3^\star$	1.9_4	1.9_4	2.0_4
ε_{r^p-r}	r^p-r	$3.6_0^\star$	$3.6_0^\star$	$3.6_0^\star$	$11.7_2^\star$	$12.0_2^\star$	$12.0_2^\star$

NOTE. x_j gives the maximal cumulative effects of shocks to the indicated innovations on the indicated variables under various assumptions about causality. j indicates in what j-step ahead period the cumulative effect is maximal. The columns refer to different orderings of innovations, where VAR 1 is our baseline assumption (see the text for details). *denotes statistical significance at the 5-percent level.

TABLE 6: Granger Causality F-Tests

	Δs_t	Δp_t	$\Delta(r_t^p - r_t)$	$\Delta(r_t^s - r_t)$
Δs_t	.	2.27	0.71	1.26
Δp_t	$6.32^{\star\star}$	.	0.74	0.19
$\Delta(r_t^p - r_t)$	$6.42^{\star\star}$	$5.54^{\star\star}$	.	0.21
$\Delta(r_t^s - r_t)$	$4.51^{\star}$	$4.79^{\star}$	0.61	.
Δpr_t	$8.58^{\star\star}$	$3.09^{\star}$	1.34	1.40
Δcr_t	2.94	1.58	1.36	2.69

NOTE. H_0: The row does not Granger cause the column. *and **denote statistical significance at the 5- and 1-percent levels, respectively.

TABLE 7: Long-Run Effects (Vector Error Correction)

		Vector Error Correction					
Shock to	Effect on	VEC 1	VEC 2	VEC 3	N&T 1	N&T 2	G-R
		Percent					
ε_s	s	9.6	9.8	11.5	.	0.3	.
ε_p	s	5.3	5.2	6.7	.	.	.
ε_{r^s-r}	s	11.0	11.0	8.2	.	.	.
ε_{r^p-r}	s	3.3	3.0	3.0	.	1.7	.
ε_s	p	14.0	14.0	15.6	.	.	.
ε_p	p	13.6	13.6	14.8	0.0	.	2.2
ε_{r^s-r}	p	10.2	10.2	5.2	.	.	7.7
ε_{r^p-r}	p	0.4	0.4	0.4	1.3	.	.
		Basis Points					
ε_s	r^s-r	1.9	1.9	3.0	.	.	.
ε_p	r^s-r	−2.6	−2.6	−1.4	.	.	2.8
ε_{r^s-r}	r^s-r	6.7	6.9	6.8	.	.	9.9
ε_{r^p-r}	r^s-r	−0.6	−0.8	−0.8	.	.	.
ε_s	r^p-r	2.6	2.7	3.9	.	1.8	.
ε_p	r^p-r	−2.7	−2.9	−1.6	0.1	.	.
ε_{r^s-r}	r^p-r	7.2	7.2	7.1	.	.	.
ε_{r^p-r}	r^p-r	2.8	2.5	2.5	12.0	9.4	.

NOTE. The table gives the long-run effects of shocks to the indicated innovations on the indicated variables under various specifications and assumptions about causality. The columns refer to different specifications. VEC 1: [ε_{r^s-r}, ε_{r^p-r}, ε_s, ε_p]. VEC 2: [ε_{r^s-r}, ε_s, ε_p, ε_{r^p-r}]. VEC 3: [ε_s, ε_p, ε_{r^s-r}, ε_{r^p-r}]. N&T 1: [ε_p, ε_{r^p-r}]. N&T 2: [ε_s, ε_{r^p-r}]. G-R: [ε_p, ε_{r^s-r}].

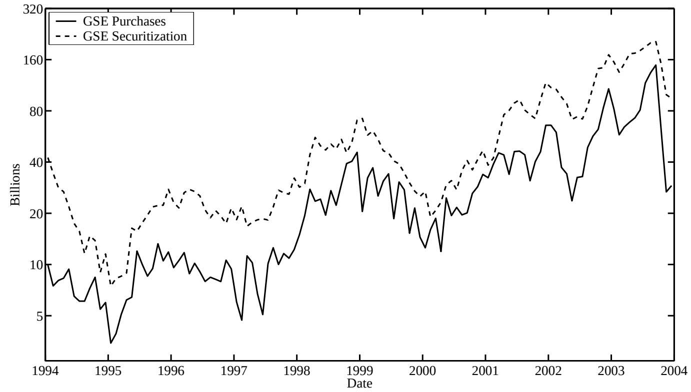
TABLE 8: Maximal Effects (Vector Error Correction)

Shock to	Effect on	VEC 1	VEC 2	VEC 3	N&T 1	N&T 2	G-R
		Vector Error Correction					
		Percent					
ε_s	s	14.7_0	14.7_0	14.9_0	.	5.5_0	.
ε_p	s	7.4_2	7.2_2	8.3_2	.	.	.
ε_{r^s-r}	s	12.4_4	12.4_4	9.5_4	.	.	.
ε_{r^p-r}	s	3.5_4	3.4_4	3.4_4	.	2.3_5	.
ε_s	p	14.2_8	14.2_8	15.8_5	.	.	.
ε_p	p	25.4_0	25.5_0	25.9_0	5.1_0	.	10.7_0
ε_{r^s-r}	p	13.7_2	13.7_2	9.0_2	.	.	7.7_{24}
ε_{r^p-r}	p	1.0_2	1.0_3	1.0_3	1.4_3	.	.
		Basis Points					
ε_s	$r^s - r$	2.1_6	2.1_6	3.1_5	.	.	.
ε_p	$r^s - r$	-3.0_5	-2.9_5	-1.8_6	.	.	2.8_{24}
ε_{r^s-r}	$r^s - r$	9.9_2	9.9_2	9.8_2	.	.	10.9_2
ε_{r^p-r}	$r^s - r$	-0.7_6	-0.9_6	-0.9_6	.	.	.
ε_s	$r^p - r$	2.8_6	2.9_6	4.0_6	.	2.4_5	.
ε_p	$r^p - r$	-3.1_6	-3.2_6	-2.1_6	-0.8_2	.	.
ε_{r^s-r}	$r^p - r$	10.7_1	10.7_1	10.3_2	.	.	.
ε_{r^p-r}	$r^p - r$	3.6_0	3.5_0	3.5_0	12.3_2	11.7_2	.

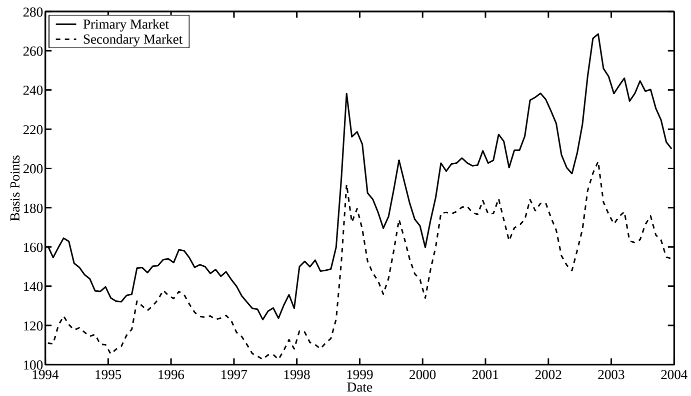
NOTE. x_j gives the maximal effects of shocks to the indicated innovations on the indicated variables under various assumptions about causality. j indicates in what j-step ahead period the effect is maximal. The columns refer to different orderings of innovations (see the text for details).

FIGURE 1: Data

(a) GSE purchase and securitization volume (log scale).



(b) Primary and secondary mortgage market spreads to Treasury rates.



(c) Credit and Prepayment Characteristics.

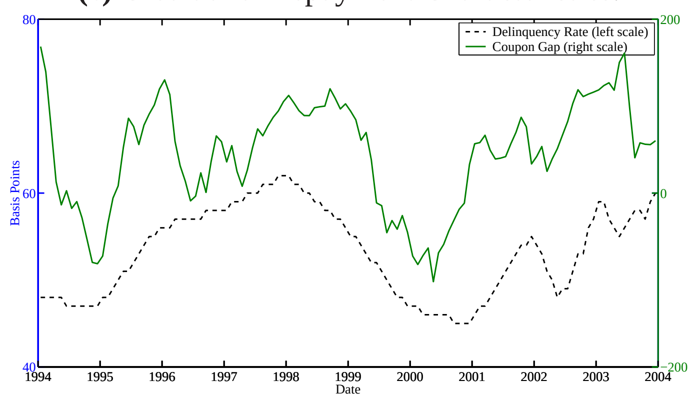
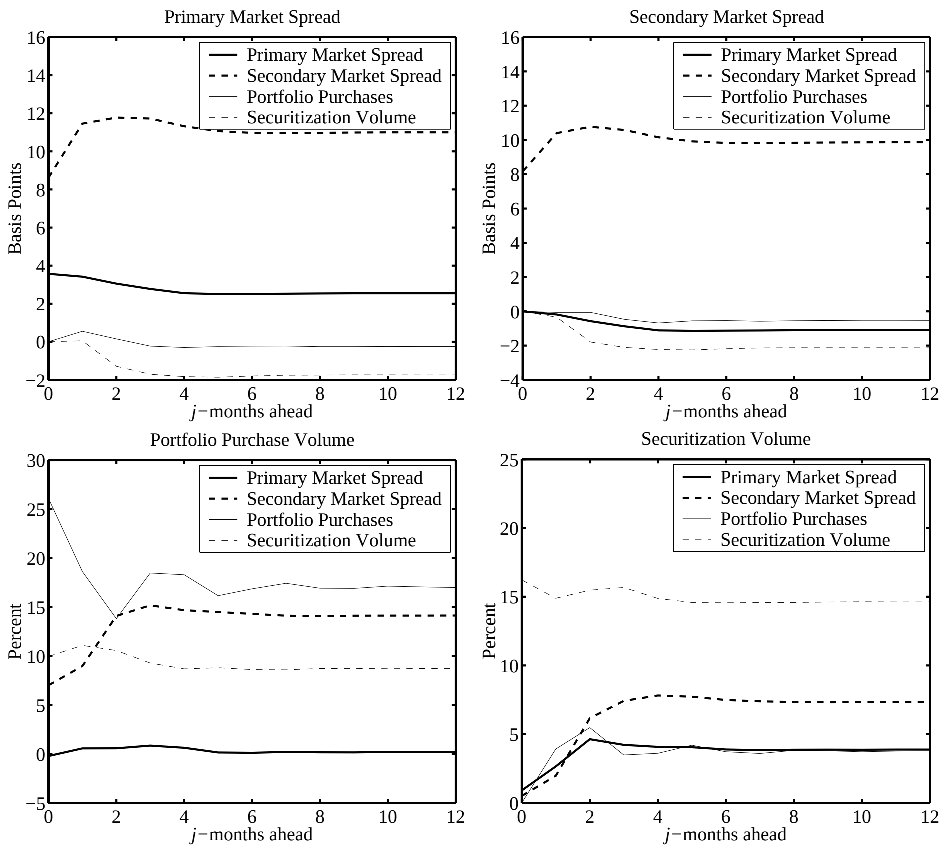
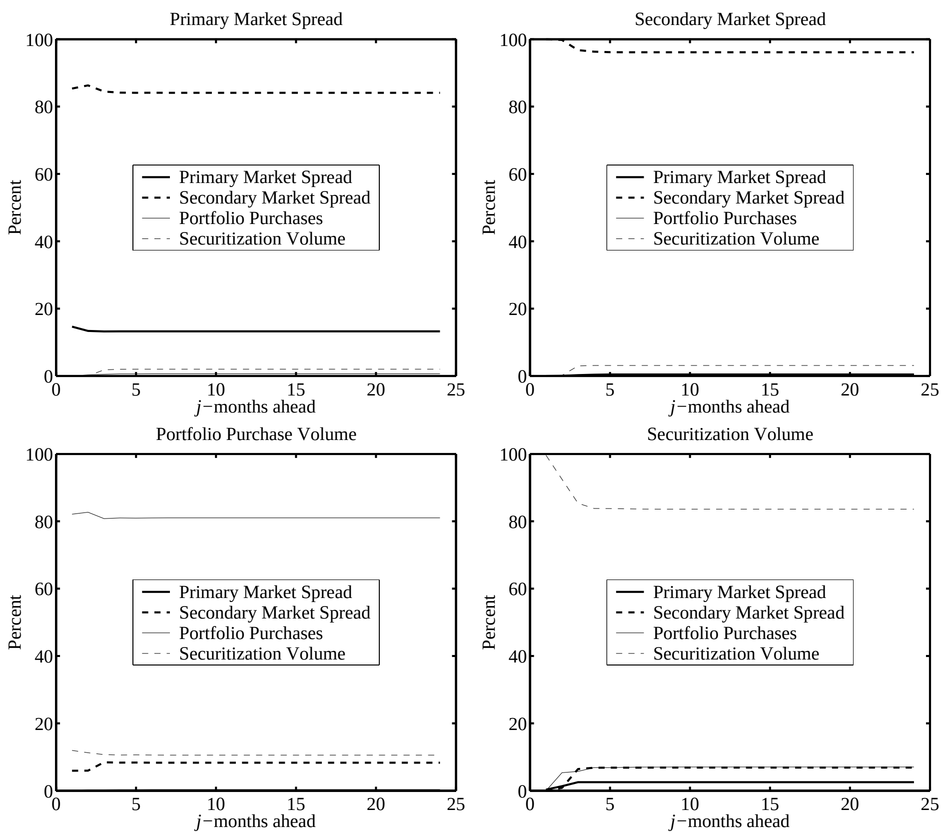


FIGURE 2: Cumulative Impulse Response Functions



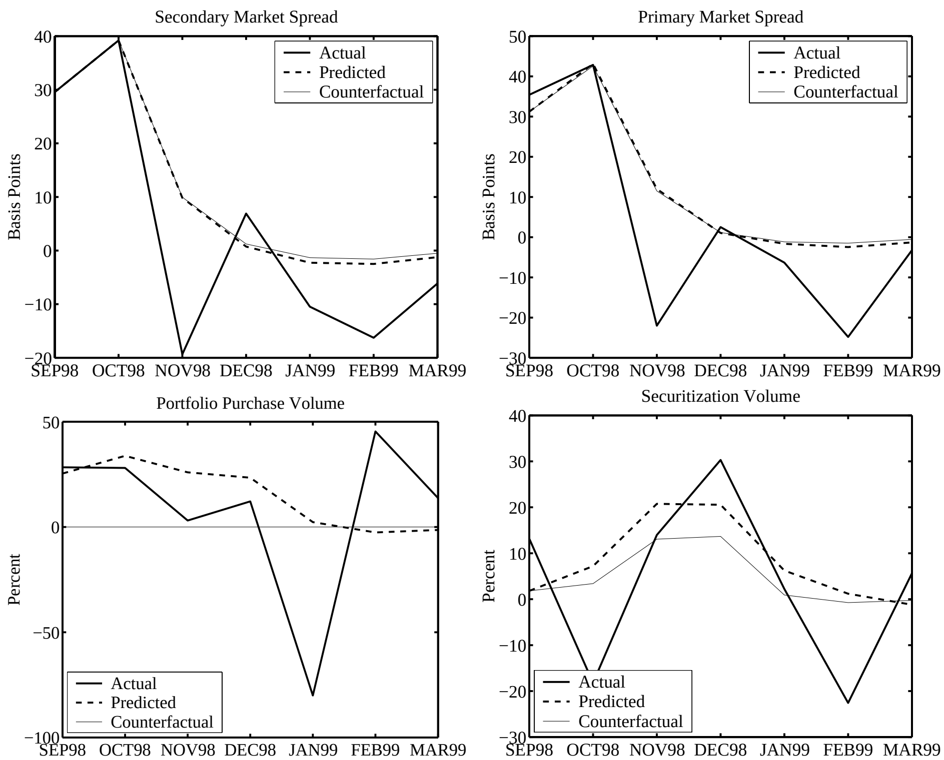
NOTE. Each panel gives the cumulative effect in month j for a given variable of a shock to the indicated equation. Thus, the dashed thick line in the upper left panel shows the effect on primary market spreads of a one standard deviation shock to secondary market spreads. Note that these impulse response functions were estimated under our baseline assumption about causation (see section 4.2 for more details).

FIGURE 3: Variance Decomposition



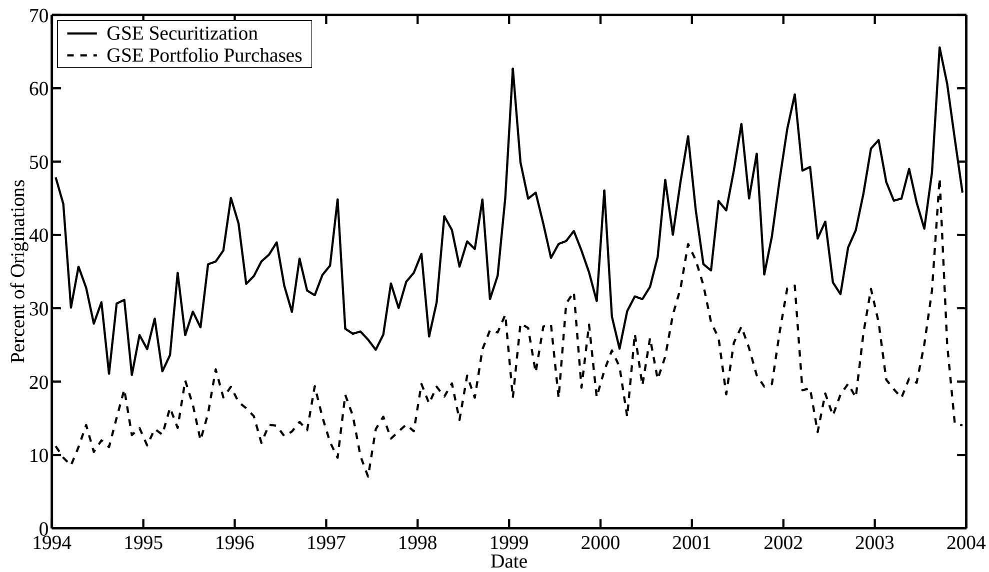
NOTE. Each panel gives the fraction of the $j-$month ahead forecast error variance for a given variable that can be explained by innovations to the indicated equations.

FIGURE 4: Response to Liquidity Crisis of 1998



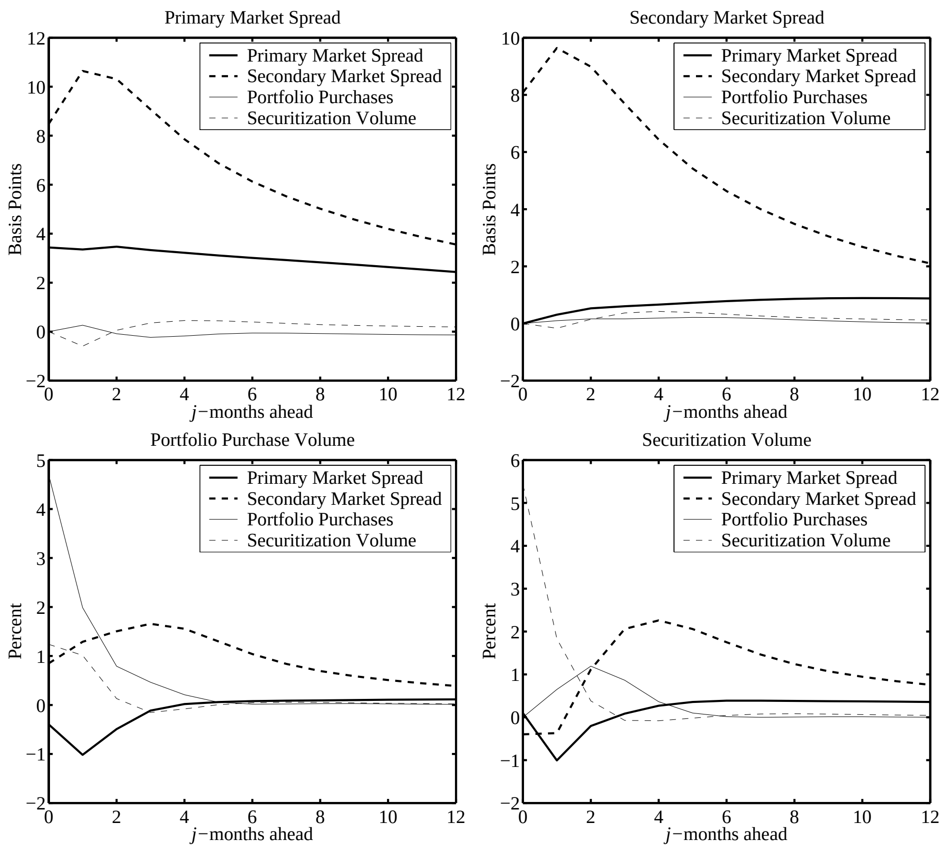
NOTE. Each panel gives the month-by-month effects of the liquidity shock to secondary mortgage market spreads. Thus, the lower left graph shows that the model does remarkably well in tracing out the effects of the liquidity shock on GSE portfolio purchases. These impulse response functions were estimated under our baseline assumption about causation (see section 4.2 for more details).

FIGURE 5: Normalized GSE Actions



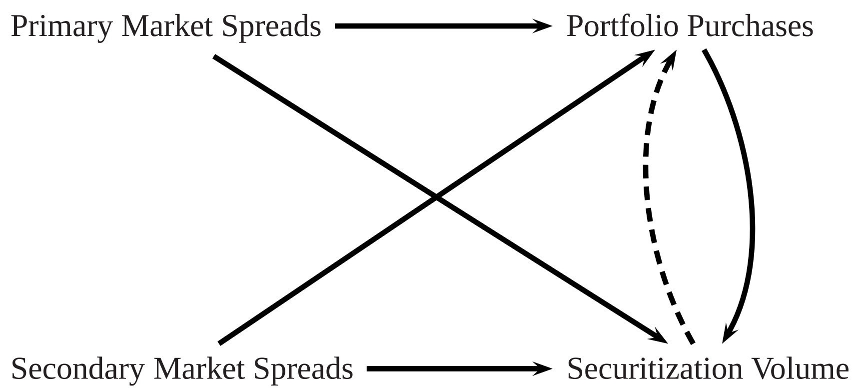
NOTE. Figure shows monthly total GSE portfolio purchases and gross MBS issuance divided by estimated monthly total mortgage originations derived from the HMDA reports.

FIGURE 6: Impulse Response Functions Under the Levels Specification



NOTE. Figure shows the impulse response functions of endogenous variables to normalized shocks under the level specification. See section 4.5 for more detail.

FIGURE 7: Granger Causality Test Results



NOTE. Arrows show the direction of causality from bivariate Granger tests. (Dashed line indicates marginal statistical significance.)

FIGURE 8: Cointegrating Relationship