The U.S. Housing Bubble: Implications for Monetary Policy and the Global Supply of Saving

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A VAR framework is used to determine impacts of key variables thought to have impacted house prices around the time of the housing boom. Separate models are used to capture traditional and nontraditional policies monetary policies during that time. Results show house prices respond to shocks in the federal funds rate and increases in the Fed's balance sheet as well as shocks in net capital inflows but do not move in response to changes in mortgage or delinquency rates. The inclusion of higher lag orders is necessary to capture the delayed response of important variables affecting the housing market.

Keywords: Monetary Policy, VAR, Housing Prices, Housing Bubble, Global Savings Glut Hypothesis

INTRODUCTION

The housing market plays a vital role in the economy through the monetary transmission mechanism. Mishkin (2009a) provides an excellent explanation of the monetary transmission mechanism in which he discusses how monetary policy affects the housing market either directly or indirectly through at least six channels and demonstrates how the user cost of capital is a determinant of residential housing demand by using a standard neoclassical model. When monetary policy decreases short-term interest rates, long-term interest rates tend to fall because of their link with expectations of future short-term rates. This causes a decrease in user cost of capital and increases housing demand. This increase in housing demand results in an increase in housing starts, which, in turn, increases the economy's aggregate demand. Mishkin contends that policy makers need to understand the role of the housing market in the economy in order to achieve maximum employment and price stability.

Financial innovation and growth in the secondary mortgage markets has caused the housing market to have an even greater role in the economy than in the past (Miles, 2009). Consequently, a shock in the housing market can impact the entire macroeconomy. There are four channels through which a downturn in the housing market affects the macroeconomy (Hatzius, 2008). For example, a downturn in home values directly lowers output through decreased residential investment. Spending on goods and services can be reduced due to an increase in unemployed workers linked to the housing market through construction and real estate. The housing downturn can cause a wealth effect in consumption from changes in home values. Lastly, the decreased home values can cause losses in mortgage credit due to a reduction in lender's capital thus decreasing capital available to borrowers.

The United States began to experience a rise in real house prices beginning in March of 1996. During this time, house prices rose on average, by over eleven percent per year from 1997 through the peak of the housing boom in January of 2006. In 2005 alone, house price inflation escalated to a staggering eighteen

percent. House prices continued to rise until December 2006 when the U.S. housing market inevitably collapsed, triggering an eighteen-month recession.

Common culprits blamed either solely or, in part, for their contributions to the rapid growth of prices in the housing market during this time are: excessively loose monetary policy, increases in capital inflows from foreign investors, fiscal policies aimed at increased home ownership, large scale purchases and securitizations of mortgages from government sponsored entities like Fannie Mae and Freddie Mac, low mortgage interest rates, and lastly, high mortgage acceptance rates for non-optimal credit risks, otherwise known as subprime mortgages.

The Federal Reserve has been criticized for its policy of extremely low interest rates during the early part of the century. It is commonly agreed upon in the literature that from 2001-2004, the federal funds rate was well below what would have been predicted during the time of the Great Moderation. Bernanke (2010), Greenspan (2004) and Brunnermeier (2008), among others argue that the low rates were necessary in the wake of the September 11, 2001 terror attacks, to combat the recession after the bursting of the Internet bubble and fear of deflation. Williams (2015, 2016), among others, concludes that monetary policy is appropriate given that the neutral interest rate has fallen in recent years.

Proponents of the Fed's policy actions during this time argue that the low rates played little or no role in the rapid inflation of U.S. house prices. Conversely, some economists such as Taylor (2009), McDonald and Stokes (2013a), and White (2009) contend that it was, in fact, the low interest rates that fueled the run-up in house prices and helped sustain the above-average growth in the housing markets.

Building upon previous empirical studies examining the effects of monetary policy on house prices during the housing boom, I estimate a structural vector autoregressive (VAR) model with monetary and housing variables to examine the impact these variables had on house prices. This study takes a different approach from existing literature identifying determinants of house price movements during this time. Previous studies using VAR methodology use a single variable to measure the stance of monetary policy in an attempt to reveal the relationship between house prices and the federal funds rate. In this study, I test the effects of the Fed's policy actions on housing by using two measures of monetary policy. Prior to the recession of 2008-2009, the Fed adjusted the target federal funds rate up or down in order to achieve desired macroeconomic results. Since 2008, however, the Federal Reserve has introduced new policy measures that had previously never been used. Most notably of these, was the introduction of large-scale asset purchases (LSAP), referred to as quantitative easing (QE) due to the shift in the focus of monetary policy to quantity targets. Therefore, two policy variables are now necessary in order to capture the effects of not only the conventional, but also the unconventional policies enacted by the Federal Reserve in recent years.

I estimate two forms of a structural VAR using the empirical methods employed by Bernanke and Blinder (1992). The first model includes the effective federal funds rate as the monetary policy variable. I then re-estimate the model with an alternate measure of monetary policy. Open market operations can be measured through changes to the Fed's balance sheet. Federal Reserve bank credit captures conventional open market operations as well as purchases beyond traditional Treasury securities during the various rounds of quantitative easing as well as other nontraditional monetary policies initiated by the Fed after the bursting of the bubble in the housing market and the subsequent financial crisis that followed. A benefit of splitting the model is that it allows for analysis of each component of monetary policy separately. The federal funds rate captures monetary policy actions through the bubble period and Reserve bank credit captures the Fed's post-bubble policies.

A VAR framework allows consideration of two questions about the stance of monetary policy. Was monetary policy too loose during the housing bubble and if so, was it was a major contributing factor to the run-up in prices in the housing market. Additionally, the use of a VAR framework provides the ability to test some of the alternative hypotheses of other possible contributing factors to the housing bubble in addition to the monetary policy variables.

I present two sets of empirical results. The results from Model 1 provide evidence that the federal funds rate was a contributing factor to the movement in house prices. The results presented for Model 2 provide evidence that the unconventional monetary policy on the part of the Fed also has an effect on

housing variables. I improve upon existing models by using a time period that is long enough to encompass the entire housing bubble but short enough to ensure stability in the results. The house price index variable and optimal lag length are chosen using econometric selection criteria.

Both short term and long-term mortgages rates as well as the mortgage delinquency rate are included in the models. Neither the 30-year conventional nor the 1-year adjustable mortgage rates are found to affect price movements in the housing market. The long-term mortgage interest rate is highly sensitive to changes in short-term rates of the Fed funds rate and the 1-year ARM, however. Much of the variation in the 30-year fixed mortgage rate is due to both short-term rates. As expected, an increase in the delinquency rate for mortgage payments has a negative impact in the housing market.

The results presented in this study also lend support to Bernanke's GSG hypothesis. The global savings glut (GSG) refers to the significant increase in the global supply of saving. Bernanke (2005; 2011; 2007) ascribes the reduction of long-term interest rates to the increase in capital inflows into the United States from Asia and the Middle East countries dubbed GSG countries. According to Bernanke's "global savings glut hypothesis," capital inflows from foreign investors helped hold down long-term interest rates, including mortgage rates, particularly during 2003-2007 (Bernanke, Bertaut, DeMarco, & Kamin, 2011).

Net capital inflows are found to Granger cause house prices in both models. Shocks to the long-term mortgage interest rate show an immediate positive response to net capital inflows. The response to house prices to a shock in net capital inflows however, is significantly positive, but only after eighteen months suggesting a lag in the time for prices in the housing market to react to the surge in inflows from foreign investment.

MONETARY POLICY VARIABLES

Bagliano and Fevero (1998) evaluate VARs designed to estimate the monetary policy transmission mechanism and conclude that only models containing one policy variable do not show signs of parameter instability or evidence of misspecification. Building upon this result, I specify separate models to determine effects of both the Fed's interest rate policy, as well as its non-traditional monetary policies. Measuring the effects of both federal funds rate targeting policy as well as unconventional monetary policy will determine not only the relationship between these variables and house prices during the years in which house prices were rising, but will also capture the period following the collapse of the housing market.

The evidence provided in this study support the findings in the empirical study by Fitwi, Hein and Mercer (2015). Fitwi, Hein and Mercer develop a reduced-form pricing equation for U.S. house prices. They add a measure of monetary policy and an international capital inflow variable to determine if either or both of the variables explain the cyclical behavior in the housing market during the housing bubble and find evidence supporting both explanations.

In December 2008, the Federal Reserve began using more nontraditional policy tools when they initiated the first round of quantitative easing, now known as QE1. QE1 lasted twenty-one months ending in August 2010. QE2, the second round of quantitative easing, was announced in October 2010 and lasted seven months. A Maturity Extension Program, often referred to as Operation Twist, was aimed at increasing the maturity of the Fed's treasury portfolio and was announced in September 2011 and extended in the summer of 2012, finally ending in December 2012. The final round of quantitative easing, QE3 was announced in September 2012 and ended in October 2014. QE1 differs from the other QE rounds because of the composition of the purchases. QE1 was comprised of purchases of direct obligations of housing-related government-sponsored enterprises (GSEs) and mortgage-backed securities (MBS). The first round of quantitative easing was intended to increase the availability of credit and improve the overall housing market by purchasing $1.25 trillion in MBS, roughly doubling the size of the U.S. monetary base. QE2 expanded the Fed's holdings in longer-term Treasury securities and was intended to support the economic recovery. During QE3, the Fed agreed to purchase an additional $40

billion in MBS and continue Operation Twist. Operation Twist ended by rolling over short-term bills in addition to purchasing $85 billion in long-term treasuries and MBS.

Since monetary policy actions can no longer be captured completely by the federal funds rate after quantitative easing began, an additional variable to capture monetary policy actions is now necessary. There are several options to attempt to capture the effects of quantitative easing. One possibility is to use dummy variables for the QE periods. This method follows the "narrative approach" used by Romer and Romer (1989) in which they create dummy variables for periods of explicit contractionary monetary policy actions intended to combat inflation. One of the benefits to this approach as noted by Bernanke and Mihov (1995), is that it is not necessary to model the details of the Fed's operating procedures in order to implement the procedure. A drawback to this method, however, is that the use of dummy variables does not measure the magnitude of the large-scale asset purchases. Another potential pitfall is that dummy variables for the QE's would only be able to show significance during these periods but would not necessarily indicate that it was in fact due to the quantitative easing instead of some other factor not captured in the model.

Another possibility to measure the Fed's QE policy is to directly measure the purchases by the Federal Reserve. Christiano and Eichenbuam (1991) suggest the use of non-borrowed reserves as a measure of monetary policy. Non-borrowed reserves, according to Bernanke and Mihov may be the Fed's most closely controlled instrument. Essentially, by purchasing assets, the central bank is expanding its balance sheet. Federal Reserve Bank credit (RBC) not only captures the LSAPs of the Fed during quantitative easing but also captures the Fed policy actions through its Term Auction Facility. (TAF).

The TAF was a temporary program instituted in December 2007 by the Federal Reserve to increase liquidity in the credit markets in response to the problems associated with the subprime mortgage crisis. TAF funds were auctioned to banks. The Fed initially engaged in defensive open market sales to keep the monetary base stable. Thus, discount lending increased and open market security holdings decreased by equal amounts. TAF lending was sizable, so using only open market security holdings would inaccurately reflect all of Fed policy at this time.

Federal Reserve Bank credit (RBC) is comprised of purchases of government securities, loans to the banking system, float and other miscellaneous activities. Federal Reserve holdings of securities make up the bulk of RBC. Monthly data for RBC, captures not only the purchase of the large-scale assets (LSAP) purchased through the various QE's and the sizable TAF lending, but RBC also historically measures the holdings of Treasury securities. Using RBC as a policy variable will determine any impact and magnitude of non-traditional monetary policy actions through the various rounds of quantitative easing on other variables in the model.

Separate models are also necessary in order to correct for serial correlation persistent in a model comprising of both monetary policy variables. Both the federal funds rate and the open market operations of the Fed through buying and selling of assets are ways to measure monetary policy. Therefore, it is expected that including both variables in the model would produce some degree of correlation among the variables. Therefore, I specify two separate models using alternative measures of monetary policy.

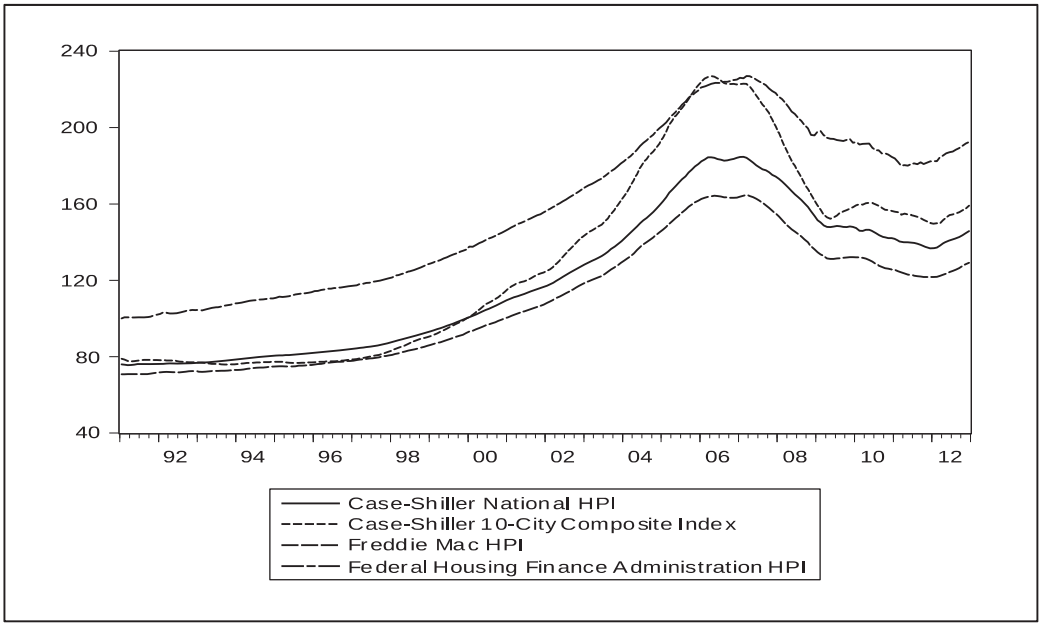
DATA

McDonald and Stokes (2013c; 2015) group the literature on the housing bubble into four categories. The first of these categories is the financial sector. This area of literature focuses on contributions on the part of the financial sector through unsound lending practices, high degrees of financial leverage and short-term borrowing and the issuance of complex mortgage-backed securities. Another major category in the literature is those that support the views of Bernanke's (2007) global savings glut hypothesis. The argument is that the flood of foreign capital that resulted in a trade deficit pushed up asset prices in the housing market. Then there are those like Shiller (2007) who claim that the housing bubble is a classic asset price bubble that had its own momentum until its inevitable crash. The final category attributes blame to fiscal and monetary policies. The government gets its share of the blame through deregulation

and lax use of existing regulations as well as the federal government's aggressive policy to increase the rate of homeownership.

I specify a VAR model with housing prices, monetary policy variables, and also variables to test some of the hypotheses propounded in previous studies. Bernanke (2007) demonstrates how the inflows from foreign investment strongly impacted house prices during the sample period studied in this paper. Consequently, I include net capital inflows in the VAR as an endogenous variable. Miles (2014) contends long-term mortgage rates have a predictive power on house prices. McDonald and Stokes (2015) demonstrate the impact of short-term ARM rates on house prices and the importance of including a longer lag length to capture slow adjustment to changes in key variables in the model. Building upon many of these specifications, I include both the 30-year fixed mortgage rate as well as the 1-year adjustable-rate mortgage (ARM) to attempt to address the inconsistencies in the conclusions drawn from Miles and McDonald and Stokes as well as Bryant and Kohn (2013) and Payne (2006) as to the impact of mortgages rates on house prices during the housing bubble. No other study to my knowledge includes specifications to capture all of the non-traditional policies used by the Fed during this time nor has the delinquency rate been considered as a potential contributor to movements in house prices.

FIGURE 1
FEDERAL FUNDS RATE AND MORTGAGE INTEREST RATES, 1991-2012



I use an econometric approach for selecting the house price index to best measure housing inflation in the United States. Only the results obtained from the VARs containing the seasonally adjusted Case-Shiller 10-city series (HPI) remained stable over time and provided consistent results[1]. The HPI is also the only index that does not present serial correlation in the lag values. The S&P Case-Shiller 10-city composite index is an aggregation of monthly changes in home prices for ten major metropolitan statistical areas (MSAs). The 10-city MSA's also saw larger upswings in prices during the housing bubble than other areas of the country. The Case-Shiller 10-city composite index is indexed with a base period of January 2000 and measures by repeat sales of single-family homes and available from the S&P Case-Shiller Indices website.

Del Negro and Otrok (2007) have argued that the housing bubble was a regionalized and not a national phenomenon. By visual inspection of the various house price indices presented in Figure 1, it is apparent that the Case-Shiller 10-city composite index was more sensitive to the upswing and downturn

in home values during the bubble period than the national average indices. The Case-Shiller 10-city series measures repeat home sales in the ten metropolitan MSA's. These areas may have experienced more or a sharp run-up and subsequent crash than the other areas of the country. The national average indices may reflect the issue of spatial heterogeneity in house prices across the United States during the housing bubble (Glaeser & Nathanson, 2014).

Changes in interest rates can lead to reactions on the parts of investors and savers through the monetary transmission mechanism. If rates are low, demand for borrowing increases. Various forms of adjustable rate mortgages (ARMs) became increasingly cheap relative to 30-year fixed rates. By 2006, about one quarter of all new mortgages were ARMs and three-fourths of the ARMs were considered subprime.

In July 2011, approximately one-third of all home sales were the result of foreclosures. As part of a federal stimulus packages indented help in the economic recovery after the crash of the housing market, almost $50 million was allocated to a mortgage rescue plan in 2009. This legislation was intended to help homeowners who were delinquent on their mortgage payments stay in their homes by allowing them to make loan modifications to their existing mortgage. Homeowners who were current on their mortgage but unable to refinance due to home values falling below their existing loan amount could qualify for the government-refinancing program. Refinancing and loan modifications helped reduce the foreclosure rate while the delinquency rate has remained fairly high. Data on average foreclosure rates did not become available until 2000, however. The mortgage delinquency rate can be an early indicator of housing foreclosures, however. The delinquency rate on single-family residential mortgages is an average delinquency rate for all domestic commercial banks and measures the percentage of loans that are 30 days or more past due. This rate captures all types of mortgages and does not distinguish between prime and subprime mortgages.

Seasonally adjusted quarterly data for net capital inflows (NCI) of foreign assets in the US, measured in billions of dollars, is interpolated into monthly values and is obtained from the U.S. department of the Treasury. The quarterly mortgage delinquency rate, which was interpolated to monthly values, as well as Reserve Bank credit (RBC) and the effective federal funds rate (FFR) are obtained from the Federal Reserve Board of Governors. The 1-year adjustable rate mortgage (ARM) average and 30-year fixed conventional mortgage rate (FRM), is available from Freddie Mac.

NCI is measured in levels as the variable can take on negative values. All other variables are measured in log values. I use monthly data beginning in 1991, as this was the first year all key variables in the models are available. I extend the period through 2012, several years after the burst of the housing bubble. This sample period is necessary as it not only captures any contributions on the part of key variables to the increase in housing inflation, but also contributions to the collapse in the housing market as well as a possible run-up in house prices as seen by the upswing of house prices since 2011.

Table 1 presents descriptive statistics for the data for the entire sample period as well as three sub-periods. By splitting the sample into sub-periods, it is easy to see variations in the variables vary before, during, and after the bubble. As shown in Panel A, the FFR shows great variation during the entire sample period ranging from a high of almost seven percent to low of near zero percent. The huge spike in RBC starting in 2008 signifies the acquisition of assets by the Fed reaching a high of over 2.5 trillion dollars by the end of the second quarter of 2011. The delinquency rate also displays excessive volatility in the full sample period with a low of 1.39 % in the fourth quarter of 2004 to a high of 11.27 % in 2010.

The Federal Reserve has expanded its balance sheet by an astronomical 195% during the various QE rounds based on mean values of RBC in the housing bubble period. Mortgage interest rates remained low after the bursting of the bubble. In fact, the spread between the short-term and long-term rates was only 88 basis points on average from 1997 through 2012 with the 30-year fixed rate dropping as low as 3.3% by the end of 2012.

Panel B provides statistics for the period prior to the housing bubble. Prior to 1996, house prices had been fairly stable. The average delinquency rate on mortgages was under 3% with the highest rate of 3.36%, which occurred in 1991. The spread between the 1-year adjustable ARM and the 30-year fixed mortgage rate was almost 250 basis points.

Panel C describes the years during the housing bubble. House price inflation increased by over seventy percent from years prior to the bubble and hit an all-time high of a 226-index value at the peak of the bubble in March 2006. Although the Federal Funds rate hovered under 2% for over two years after 9/11 and even dipped down below 1% in December 2003, the average rate during the bubble period was just under 4% with a high of 6.54% in July 2000. During the almost ten-year span of the bubble, the spread between the 1-year ARM and the 30-year fixed rate had shrunk to only 157 basis points and average delinquency rate on mortgages fell to under 2%. Net capital inflows during the housing bubble are 140% larger than average inflows in the pre-bubble period.

Panel D describes the period after the peak of house prices in March 2006. The mortgage delinquency rate was relatively low until after the bursting of the housing bubble in 2007. Subsequently, the delinquency rate rose from less than 2% to over 8% of mortgages on average with a high of 11.27% in the first quarter of 2010.

TABLE 1
DESCRIPTIVE STATISTICS

Panel A: 1991-2012

	Months	Mean	Max.	Min.	Std. Dev.
HPI	264	130.2	124.4	226.9	75.8
FFR	264	3.35	3.75	6.91	0.07
RBC	264	792	523	2650	241
ARM	264	5.08	5.29	7.74	2.54
FRM	264	6.67	6.78	9.64	3.35
INFLOWS	264	1.73	1.63	5.11	-1.03
DELINQ	264	3.81	2.29	11.27	1.39

Panel B: Pre-Bubble (1991-2/1996)

	Months	Mean	Max.	Min.	Std. Dev.
HPI	62	77.1	77.0	78.9	75.8
FFR	62	4.50	4.26	6.91	2.96
RBC	62	317	319	381	241
ARM	62	5.73	5.69	7.74	4.20
FRM	62	8.22	8.32	9.64	6.83
INFLOWS	62	0.91	0.89	1.60	0.13
DELINQ	62	2.70	2.70	3.40	2.10

Panel C: Bubble Era (3/1996-12/2006)

	Months	Mean	Max.	Min.	Std. Dev.
HPI	120	134.0	120.5	226.9	77.2
FFR	120	3.94	4.80	6.54	1.00
RBC	120	564	534	776	380
ARM	120	5.27	5.53	7.29	3.41
FRM	120	6.84	6.88	8.52	5.23
INFLOWS	120	2.18	2.07	4.17	0.28
DELINQ	120	1.99	2.01	2.42	1.39

Panel D: Post-Bubble (2007-2012)

	Months	Mean	Max.	Min.	Std. Dev.
HPI	72	169.2	157.7	223.0	150.0
FFR	72	1.29	0.18	5.26	0.07
RBC	72	1612	1846.0	2650	479
ARM	72	4.16	4.32	5.71	2.54
FRM	72	5.21	5.05	6.76	3.35
INFLOWS	72	1.64	1.59	5.11	-1.03
DELINQ	72	8.04	9.95	11.27	2.03

Sources: U.S. department of the Treasury, Federal Reserve Board of Governors, Freddie Mac and S&P Dow Jones Indices.

VAR METHODOLOGY

Rigobon and Sack (2004) and Finocchiaro and Von Heideken (2013) show that incorporating house prices into a monetary reaction function introduces endogeneity into the model and produces biased estimates. Therefore, a VAR methodology is necessary to explicitly link the low fed funds rates to house prices during the housing bubble.

Rudebusch (1998) questions the results of a VAR in studying monetary policy transmission when monetary policy variables are treated as endogenous variables in the model. To properly gauge the effects of monetary policy actions, the monetary policy variables need to be exogenous in the model. Without a complete structural model of the economy, it is the response of variables to exogenous policy actions that must be examined in order to gauge the effects of monetary policy. Bagliano and Favero (1998) however, find no statistical difference between VAR models that treat the policy variables as exogenous or endogenous.

Prior to any analysis of monetary policy, I performed several specification tests. This is an important step in ensuring the VAR system is well specified to ensure the validity of the results. Bagliano and Favero (1998) show longer sample periods have parameter instability and shorter sample periods for evaluating monetary policy shocks in the economy provide more stable results. Some of the existing work on interest rates and housing bubbles use relatively short sample periods in their models consistent with the findings of Bagliano and Favero.[2] These shorter sample periods may also be due to the availability of important variables thought to play key roles in house price movements.[3] In order to capture the effects of some of these variables, sample periods are restricted to a time in which prices of homes had already started to increase dramatically or their sample periods end prior to the bursting of the bubble and therefore not capturing the entire period of the housing bubble in their sample periods but short enough to ensure stability in the results.

Questioning the conclusions made by Taylor (2007) and McDonald and Stokes (2013b), Miles (2014) attempts to determine if Fed policy was truly the main cause or even a major contributing factor of the housing bubble. Miles points out that previous empirical papers blame the Federal Reserve for the run-up and subsequent collapse in the housing market fail to include long-term interest rates. Miles estimates how well the federal funds rate can predict long-term rates. He also attempts to determine how well the federal funds rate and the 30-year mortgage rate can be used to predict housing variables and how the relationship between interest rates and housing variables has evolved over time. The filtering technique developed by Hodrick and Prescott (1997) and refined by Christiano and Fitzerald (2003) is used to decompose the variables into a stochastic trend and cyclical component. This method corrects for any non-stationary components common in the time series macroeconomic variables. Miles splits the sample periods, using the methodology of Friedman and Kuttner (1992) to follow how the relationship of interest rates and housing evolves over time. Results from regression analysis and structural change tests indicate that the mortgage rate is not a proxy for monetary policy demonstrating the declining influence of a

central bank over long-term interest rates. Long-term rates have an independent and predictive power for housing variables that at times was greater than the federal funds rate.

In reaction to criticisms made by Miles, McDonald and Stokes (2013c) attempt to justify their methods and prior results by building upon their two previous VAR models (2013a; 2013d). A VAR methodology is again used, this time adding 16 lags of all right hand and left-hand side regressors. They find shocks to the federal funds rate move house prices in a negative direction. Shocks to the federal funds rate also move mortgage rates. Shocks to mortgage rates only move house prices in a negative direction when a CF filtered data transformation similar to Miles is employed. A key finding of this study is the importance of longer lags in the VAR to capture the delay in interest rate changes and actual price movements. When mortgage rates change, there is a lag response for those with existing mortgages to refinance at the new lower rates. Their results suggest a longer VAR may be needed in order to pick up the effect.

A recursive procedure similar to that first used by Sims (1980) imposes a contemporaneous ordering of shocks. This method is consistent with the approach used by Del Negro and Otrok (2007) and Christiano, Eichenbuam and Evans (2005). A recursive ordering implies that contemporaneous values of the variables ordered to the left have an effect on the variables ordered on the right but the effect works only in one direction, so contemporaneous values of variables ordered after a variable will not have an effect on variables ordered first.

Model 1 contains the federal funds rate as the monetary policy variable to measure the effects on house prices. In addition to the federal funds rate, mortgage interest rate variables are included. McDonald and Stokes (2015) show the importance of including both short-term and long-term mortgage interest rates when identifying a structural VAR studying the determinants of house price movements. To test Bernanke's GSG hypothesis, I include a variable to measure net capital inflows. I also include a variable to assess the effect of mortgage delinquency rates on home values. To properly measure any response in house prices to shocks from the other endogenous variables in the model, I order HPI last. Variables that serve as the monetary policy measure are ordered first, followed by net capital inflows (NCI), 1-year adjustable mortgage rate (ARM), 30-year fixed mortgage rate (FRM), and delinquency rate (DELINQ). This ordering is similar to the ordering of McDonald and Stokes (2013b; 2015; 2013c) and Iacoviello (2005). As a robustness check, alternative orderings are also considered to test the sensitivity of the ordering and the results are consistent with the ordering presented.

Next, I re-estimate the model using the RBC to capture the effects of the increasing size of the Fed's balance sheet, particularly through quantitative easing. The RBC variable serves as the monetary policy measure in Model 2. The VAR includes all of the other variables and ordering as in Model 1.

I estimate a VAR (6) in first differences for all variables for Models 1 and 2. Eighteen lags are determined as the optimal lag length by AIC information criteria. This lag length is long enough to correct for serial correlation present in models with shorter lag lengths. Models with a longer lag length are non-stationary and eliminated from consideration as they could lead to spurious results.

RESULTS

Table 2 presents the results of the Granger Causality tests for both models. The results from Granger causality tests confirm the views of Allen and Carletti (2010), and Fitwi, Hein and Mercer (2015) who find the two main causes of the housing bubble are the low interest rate environment and increased debt holdings from international investors, particularly those in Asian countries. A Wald test indicates rejection of the null hypothesis of no-causality for the Fed funds rate in Model 1. The conclusion is the same for Model 2 when Reserve bank credit is used as the policy variable. *INFLOWS* are shown to Granger cause house prices in both models at the 95 percent confidence level.

TABLE 2
GRANGER CAUSALITY/ BLOCK EXOGENEITY WALD TESTS FOR HOUSE PRICES

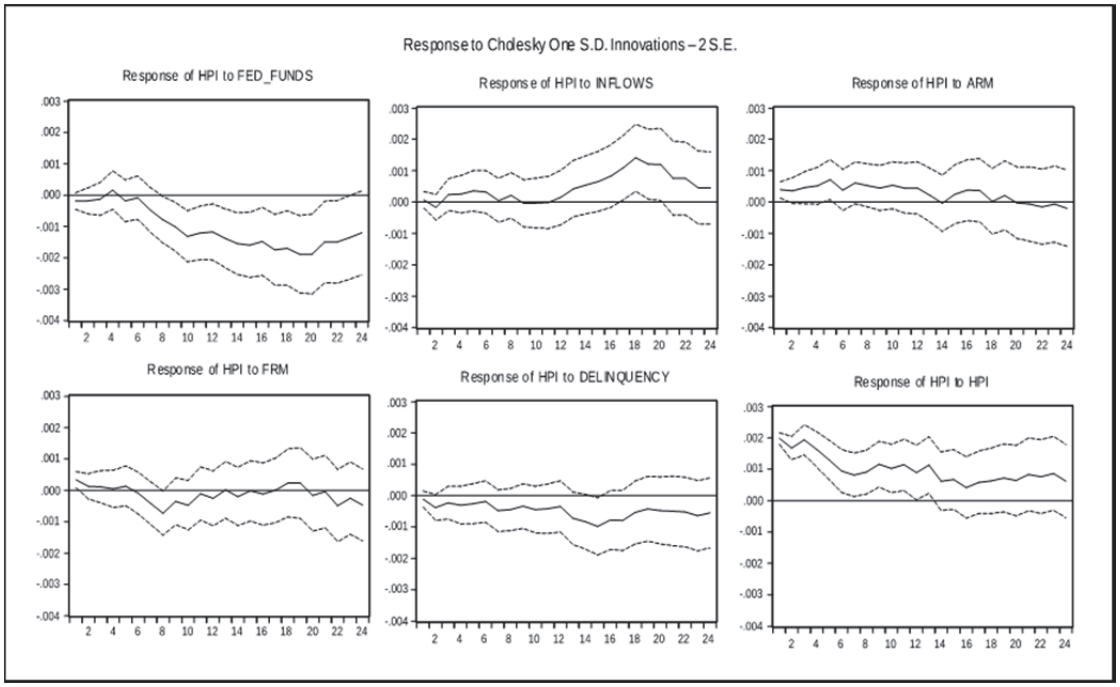
Panel A: Model 1			Panel B: Model 2		
	Chi-sq.	Prob.		Chi-sq.	Prob.
FFR	34.10	0.012	*RBC*	36.70	0.006
INFLOWS	31.57	0.024	*INFLOWS*	29.91	0.038
ARM	18.04	0.453	*ARM*	18.22	0.441
FRM	13.25	0.777	*FRM*	18.64	0.414
DELINQ	19.49	0.362	*DELINQ*	21.75	0.243
All	153.00	0.000	All	157.42	0.000

Note: Chi-squared values with corresponding probabilities are reported for 18 degrees of freedom. The sample period is 1991-2012.

A variable that is revealed to Granger cause another variable in the VAR does not necessarily imply true causality. The results merely suggest that a variable has predictive power in forecasting ability. Therefore, we now turn to other methods of structural analysis to further strengthen any conclusions from the results of the Granger causality tests.

Impulse responses trace out the present and future values of the variables in the system to a one unit increase to the errors of one of the variables in the VAR model while holding all other errors constant. The one-unit increase can be interpreted as an innovation or shock to the variable. We then can examine the dynamic response to the other variables in the VAR to the shocks.

FIGURE 3
IMPULSE RESPONSE OF HOUSE PRICES FOR MODEL 1



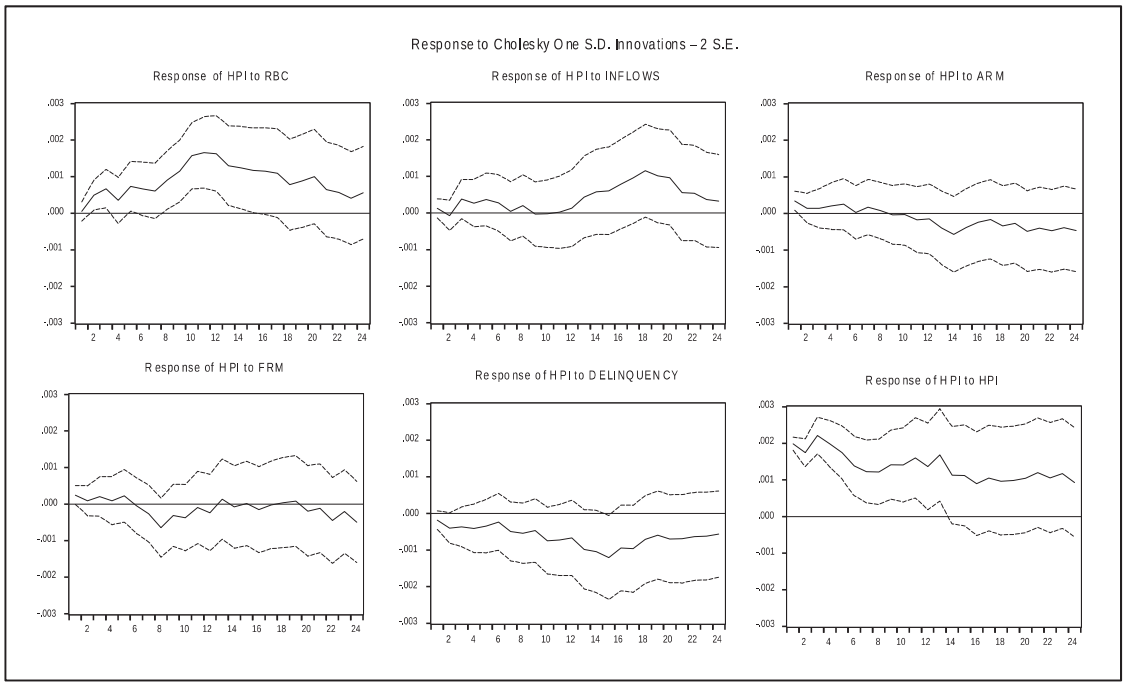
Graphs of the impulse response functions for house prices for Model 1 and Model 2 are presented in Figures 3 and 4 respectively. Asymptotic response standard error bands are added. Consistent with the results from the Granger causality tests, monetary policy shocks have an impact on the housing market. A positive shock in the fed funds rate would have a negative impact on house prices. A seen in Figure 4, a positive shock to *RBC* has a positive impact on house prices.

Both models show a slow response in house prices to innovations in the other variables in the system. House prices do not initially respond to monetary policy innovations in the interest rate. A statistically negative response is seen after about eight months. The effect of the interest rate shock persists for almost two years. The shock to *RBC* has a quicker response in *HPI* than *FFR*, but the response is small and only slightly significant.

Recall, *INFLOWS* is measured as the negative value of the balance on current accounts. Therefore, a positive shock to *INFLOWS* represents a spike in the level of foreign investment. Both models represent positive movement in house prices after a positive innovation in capital inflows indicating that a surge in foreign inflows drives up house prices. The effect is stronger and statistically significant in Model 1, however.

HPI has consistently responded to shocks in *HPI*. This result is typically expected with a shock to one's own variable. The combined result of the positive response of both *HPI* and *INFLOWS* to a positive shock to house prices could lend evidence to support the house price momentum theorists like Shiller, claiming the bubble in the housing markets took on a momentum of its own until its inevitable burst by the end of 2006. Shocks to the short-term interest rate have a positive and lasting response in the long-term interest rates.

FIGURE 4
IMPULSE RESPONSE OF HOUSE PRICES FOR MODEL 2



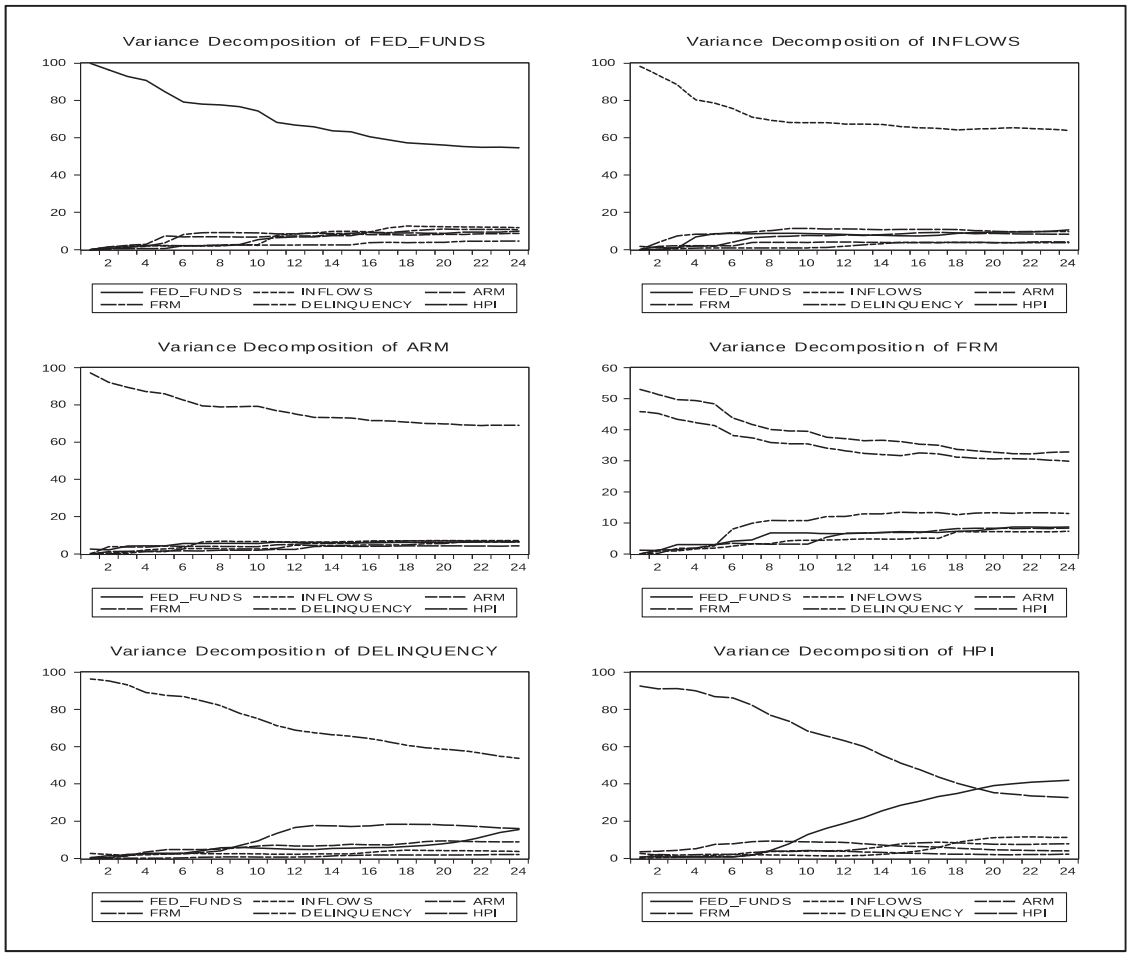
Forecast error variance decompositions (FEVD) measure the contribution of each type of shock to the forecast error variance. The variance decompositions are estimated for twenty-four months. The FEVD of Model 1 is presented graphically in Figure 5. Figure 6 depicts the graphical representation of the variance decompositions for Model 2.

In Model 1, almost all of the forecast variance for the first nine periods can be explained by the *HPI* itself. As the forecasted period continues, the fed funds rate begins to account for a greater percentage of the variation in the forecasted values of house prices. After twenty-four periods, *FFR* begins to explain almost a 28 percent of the variation in *HPI*. After about twelve months, the short-term *ARM* begins to account for a greater portion of the variation in house prices. By month 15, the *ARM* accounts for 14 percent of the forecast error variance. This amount persists through the end of the forecast indicating a lasting effect. The *DELINQ* is attributed to 15percent of the variation in house prices after 18 months.

The results for the FEVD for Model 2 show that variation in house prices is mostly attributed to house prices itself, but by period 10, *INFLOWS* accounts for roughly 10 percent of the variation. *DELINQ* and the *ARM* have slower responses but both contribute to 10 percent of the variation in HPI by the end of two years. Although *INFLOWS* does account for approximately 12 percent of the variation in HPI in Model 2, overall, the interest rate has greater predictive power in forecasting *HPI* than *INFLOWS* and only attributes a small amount of the variation in Model 1.

The *ARM* rate in plays a large part in describing the variation in the *FRM* in both models. All of the variables appear to account for variation in long-term interest rates. Particularly, the short-term rate accounts for approximately a third of the variation while the *FRM* itself only accounts for 30 percent of the variation after two years. *INFLOWS* can be attributed to 12 percent of the variance in *FRM* in Model 1 and 15 percent in Model 2. *DELINQ* accounts approximately 10 percent of the variation in *FRM* after twenty-four periods.

FIGURE 5
VARIANCE DECOMPOSITION OF HOUSE PRICES FOR MODEL 1

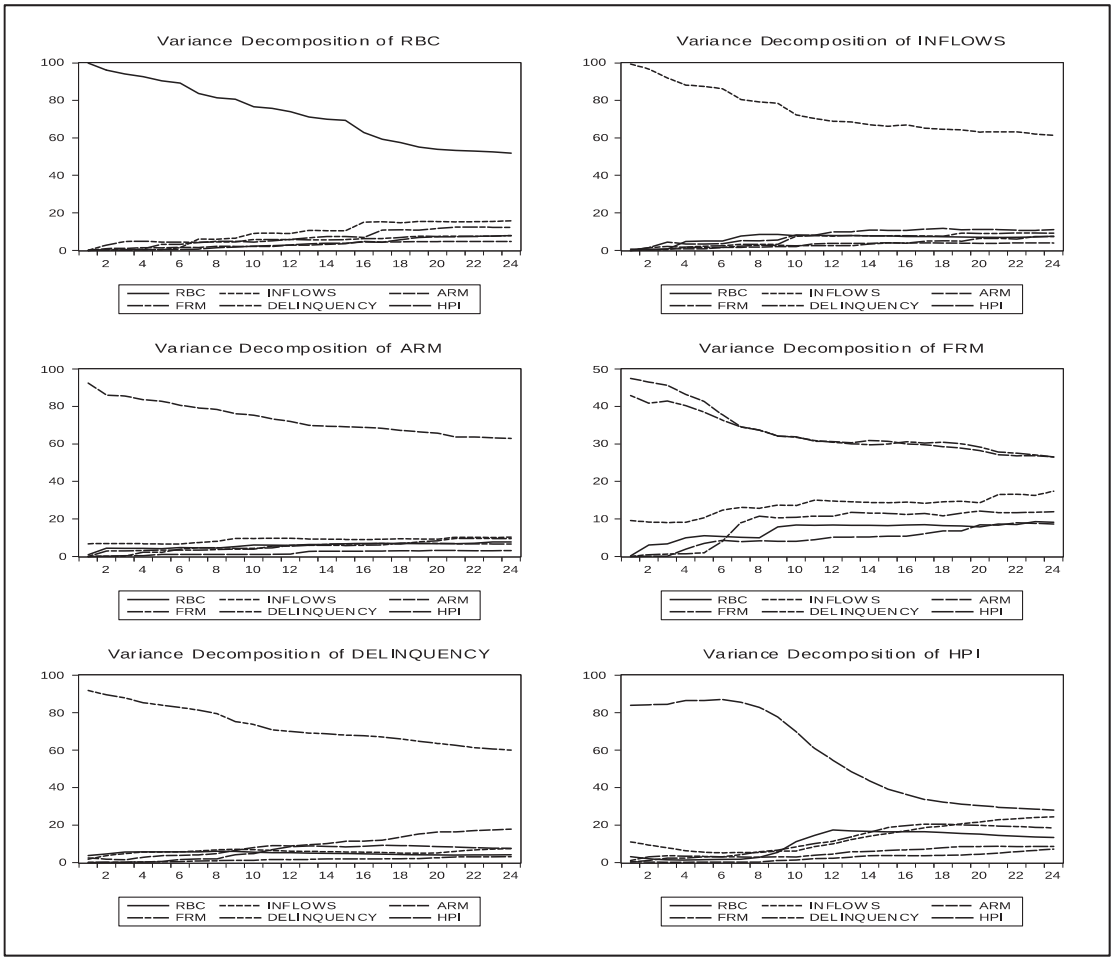


The same results are not seen in the variance decomposition of the *ARM* rate, however. Almost all of the variation in the forecast errors for the *ARM* rate can be explained by its own errors. This result is also true for *INFLOWS* and the *FFR*. Some of the variation in RBC can be attributed to *INFLOW*S but as the results of the impulse response functions show, effects of *INFLOWS* have a slow response rate. The variation in the *RBC* due to *INFLOWS* becomes larger only after year one. As expected, some of the variation in the *DELINQ* can be explained by *HPI*. These effects are only seen after about a year as well and only account for around eleven to thirteen percent of the variation.

I test the robustness of the models by specifying alternate methods of the VAR's. I restrict the sample from 1996-2012. The results for the restricted sample period show a stronger effect of the Federal Funds rate on house prices than the full sample. Dummy variables are also added for QEs and the housing bubble but do not significantly alter the results. The results are not robust to specification of house prices however. Although monetary policy variables continued to be a determinant of housing prices in alternate specifications using the other house price indices, there was no other contributing factor to house prices that was consistently present in all models. A possible explanation for the lack of consensus in the results could be the measurement methods of the various indexes. The delinquency rate is shown to Granger cause house prices in both indexes that are measured from mortgages purchased or securitized by one of the government-sponsored entities (GSE). Due to their composition, these indexes therefore may be more sensitive to delinquencies and foreclosures, especially those attributed to sub-prime mortgages that may have been purchased or securitized by Fannie Mae or Freddie Mac. These indices also may not properly capture any effect of an influx in foreign capital in the housing market. Net capital inflows are shown to be a contributing factor to house prices in both Case-Shiller series used in this study. Both Case-Shiller series are measured by repeat sales of single-family homes so the effect of net capital inflows might be better captured in one of the Case-Shiller series.

Due to the limitations of restricting the sample period to a period short enough to ensure stable results, this study does not measure the effects of monetary policy on the US housing market in recent years. Since the federal funds rate was not raised for seven years between 2008 and 2015, RBC would most likely be the better measure of monetary policy actions since 2008 and perhaps can be the focus of a future study.

FIGURE 6
VARIANCE DECOMPOSITION OF HOUSE PRICES FOR MODEL 2



CONCLUSION

This study uses a VAR methodology to examine the reaction of housing prices to variables thought to have contributed to the run-up in house prices that occurred during the ten-year period of the U.S. housing bubble. This study is unique because it incorporates separate models to capture the Fed's use of traditional and nontraditional policies. No other study to my knowledge has investigated the effect of large-scale asset purchases on the US housing market. Separate VAR specifications for each monetary policy variable are necessary due to serial correlation that persisted even after differencing the variables and increased lag orders are added. I use eighteen lags of all endogenous variables to correct for serial correlation within the model. The inclusion of higher lag orders in the VAR is necessary to capture the delayed response of important variables affecting the housing market. Eighteen months is approximately the amount of time for monetary policy to have its full effect on the economy so therefore that lag order is necessary to show the full effect of monetary policies on the housing market.

The first model uses the federal funds rate as the monetary policy measure. The second model uses Reserve bank credit in order to capture the nontraditional policies of the Fed in the years following the collapse of the housing market. Other variables included in the VAR are net capital inflows, short-term and long-term mortgage interest rates and the mortgage delinquency rate.

Although the response is greater for the federal funds rate, results show that house prices respond to both shocks in the federal funds rate as well as shocks to the Fed's balance sheet. These results by no means imply that monetary policy was the sole contributor to the extreme swings in house prices that we saw during the upsurge and subsequent burst of the bubble in the housing market. Monetary policy, particularly traditional interest rate targeting policy through its targeting of the Federal Funds rate, has an effect on house prices through the monetary transmission mechanism. The results of this study suggest that the relationship is strong but does not show an immediate effect. The inclusion of higher lag orders in the VAR is necessary to capture the delayed response of important variables affecting the housing market.

Net capital inflows also account for some of the variations in house prices as well as the long-term interest rate and lend support in favor of the GSG hypothesis. Neither the long term, nor the short-term mortgage interest rates are shown to Granger-cause house prices. The mortgage interest rates were not significant in describing the variation in house prices and shocks to the variables did not move house prices in either model suggesting that low mortgage interest rates were not a driving factor of house prices during the housing boom.

ENDNOTES

1. Other house price indexes considered were the Case-Shiller National home Price Index, The U.S. Federal Housing and Finance Agency, and the Freddie Mac and the U.S. Federal Housing and Finance Agency house price. Non-seasonally adjusted versions were also considered.
2. McDonald and Stokes focus on 2000m1-2010m8, Del Negro and Otrok's sample period is 1986Q1-2005Q4.
3. For example, data on foreclosure rates in the United States is only available beginning in 1998. The dataset for the Case-Shiller 20-City Composite Index starts in 2000.

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