Information Effects in the Monetary Policy: Based on Credit Spreads and House Prices*

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Abstract

Commonly used instruments for the identification of monetary policy shocks are likely to combine the true policy shock with information about the monetary authority's feedback rule. I show that this endogenous effect of monetary policy can give rise to the empirical puzzles reported in the literature and propose a new approach to estimating central bank preferences that account for credit spreads and house prices. To investigate whether the Federal Reserve has responded systematically to credit spreads and house prices, I use text analysis to directly measure the FOMC's objective by counting the word expressed by policymakers in their internal meetings. Next, I re-construct the Romer and Romer (2004) narrative shocks with two changes to their estimation framework and use the Local Projection estimation to trace the effects of shocks that control the endogenous response of monetary policy to credits spreads and house prices. I find that during the Great Moderation period, a monetary tightening is unequivocally contractionary, with persistent deterioration of domestic demand, labor and credit market conditions, as well as of house prices. Central to this result is that the failure to account for these endogenous reactions induces confounding in the response of all real variables to monetary policy shocks. This indicates a systematic component of monetary policy characterized by a direct and economically significant reaction to changes in house prices and corporate credit spreads.

Keywords: Monetary Policy, Local Projections, VARs, External Instruments, Text Mining, House Prices

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1 Introduction

Until recently, a central question that has consistently been posed in macroeconomic discussion is to uncover whether monetary policy is a central macroeconomic policy tool or not. It was widely accepted that the effectiveness of monetary policy is quite significant before the 1990s. A large literature has assessed the effects of monetary policy in the United States using structural vector autoregressions (SVARs), starting with Sims (1980). When considering the period from the 1950s to the early-1980s, the entirety of the post-World War II, there is a large evidence suggesting that exogenous and unexpected monetary tightens reduce real economic activities[1], which is consistent with conventional monetary theory. However, as documented in Caldara and Herbst (2019), the strength and robustness of this finding noticeably weaken when considering only data from the mid-1980s to the onset of the global financial crisis, a period of low business cycle volatility known as the Great Moderation. For instance, Boivin et al. (2010) document that monetary policy shocks have no discernible effects on the real economy, -0.7% at 24 months on output. By contrast, some literature provide evidence for monetary non-neutrality. Gertler and Karadi (2015) find sizable adverse economic effects of monetary policy tightens, -2.2% at 18 months on output. In a critical summary of research on monetary SVARs applied to the Great Moderation period, as documented in Coibion (2012) and in Ramey (2016), the estimated dynamic responses to monetary policy shocks can be sensitive to the choice of the instrument, sample, empirical specification, and the way of an identification in monetary disturbances. For the reasons, one side of recent advancement in the empirical literature on the transmission of monetary policy shocks has been the adoption of financial variables such as asset prices or credit spreads into their estimation framework to account for the endogenous reaction of monetary shocks[2]. The other side of recent empirical literature on the policy disturbances has focused on the application of informational rigidities to explain for such instabilities by adopting external instruments that can provide direct measures of the structural policy disturbances, for instance, the market surprises of Gurkaynak et al. (2005) as used in Nakamura and Steinsson (2018); and, Agrippino and Ricco (2020).

In this paper, I bring new evidence to bear on this issue. I address two questions. First,

[1]See Bernanke and Blinder (1992); Christiano, Eichenbaum, and Evans (1996); Leeper, Sims, and zha (1996); Leeper and Zha (2003); Romer and Romer (2004); and, more recently, Arias, Caldara, and Ramirez (2015).

[2]See Gertler and Karadi (2015); and, Caldara and Herbst (2019)

whether house prices and financial market conditions are included in the information set of financial authorities, and if so, to what extent. Second, whether these information effects play an important role in the overall causal effect of monetary policy shocks on real economic variables, especially for the Great Moderation period. To the best of my knowledge, this paper is the first to use both systematic components in its estimation framework. Following the works of Gertler and Karadi (2015); and Caldara and Herbst (2019), these literature have paid close attention to financial condition as an important component in the monetary authority's information set. Meanwhile, Aastveit et al. (2017) argued that the Federal Reserve has responded systematically to house prices and this response has changed over time, implying house prices are directly part of the central bank's reaction function although they've not explained the transmission mechanism of monetary policy with the information channel. In this paper, I aim to fill this gap.

An important line of this research is motivated by the idea that the failure to account for endogenous reactions from housing and financial markets induce a confounding in the response of real economic variables to monetary shocks. To deal with potential reverse causality and to identify exogenous shifts in monetary policy, I make use of the narrative monetary policy shocks with two changes to Romer and Romer's (1989, 2004) estimation framework. Based on the given policy innovation, I estimate impulse responses for real economic variables to monetary policy shocks using local projection methods (Jordà, 2005). My result shows two important findings.

First, the central bank (Fed) has responded to house prices and financial conditions for their decision-making. To reach this conclusion, this paper provides quantitative and numerical evidences of the two information frictions that are relevant for monetary policy. I formally test for the presence of systematic responses for monetary policy shocks by investigating the transcripts for each scheduled FOMC meeting from 1991 to 2008. In this step, I calculate how many the words related to housing and credit spreads are mentioned in each transcript over the sample period by applying for the standard text-mining analysis. The quantitative evidence shows that the Fed had considered house prices and credit spreads explicitly when setting up monetary policy. Specifically, I find that the house prices and credit spreads have had consistent effect on the central bank's decision-making process from the fact that those words were stated frequently in each meeting over the entire sample period. For the comparison, the numerical evidence show that narrative surprises, obtained with respect to the central bank's information set (Romer and Romer, 2004; Cloyne and

Hürtgen 2016), are affected by the information friction. To quantify that, I re-construct the original Romer and Romer (2004) shocks with two changes to their estimation framework to identify the policy shocks. Importantly, I document that the monetary policy rule reacts systematically to changes in corporate credit spreads and real house prices; all else being equal, one percent increase in spreads leads to a 0.16 percent drop in the federal funds rate target and a 1 percent increase in prices rises the target rate by an average of 0.15 percent. The evidence also shows that monetary policy rule reacts systematically to changes in credit spreads and house prices simultaneously.

Second, the size and direction of effects of monetary policy shocks to real economic variables depend on the presence of a strong systematic response of monetary policy to financial conditions and housing market. To quantify the importance of accounting for the endogenous response of policy innovation to spreads when assessing the role of monetary shocks in economic fluctuations, I estimate impulse response functions using two different methodologies, Hybrid VAR specification, in which I include the informationally-robust policy shock in a standard VAR, and Local Projection with four variants of the model: the first that omits both credit spreads and house prices for its identification strategy (a standard R&R shock), the second where monetary shocks are identified by imposing that the federal funds rate react to changes in credit spreads, Greenbook forecasts, and those revisions, the third where the shocks are identified by projecting on the changes in house prices as well as on the forecasts, the last that includes both credit spreads and house prices in the identification of policy shocks. Through these alternative specifications, I trace the effects of shocks that control the endogenous responses of monetary policy to credit spreads, house prices, or both. In the first model, the standard identification implies that contractionary monetary policy shocks induce a sustained rise in industrial production and consumption, decline in the unemployment rate, and are transmitted through loosening in financial and hosing market, which are not aligned with a conventional theory of macroeconomics. In contrast, the second and third model do not give rise to either output or price puzzles. This finding implies that shocks constructed without controlling for the response of monetary policy to either corporate spreads or house prices are misspecified, in line with the evidence in Ramey (2016). The last model provides important evidence that the attenuation occurs in the magnitude of monetary policy shocks to economic fluctuations when the shocks are not identified using both credit spreads and house prices. Though shocks are identified using credit spreads or house prices in the second third model, monetary shocks induce no discernible change in real economic variables. In contrast, the last model shows that monetary policy shocks induce a significant decline in industrial production that is 30 percent larger than in the previous specifications. The attenuation happens because a drop in corporate spreads and house prices generates a persistent increase in real activity.

My revaluation of the narrative identification of Romer and Romer (2004) clearly point to the existence of a significant systematic response of monetary policy to financial and housing market conditions beyond the well-understood response to real economic activity and prices. Through this paper, I argue that accounting for such systematic responses is crucial to understand some of the real activity puzzles in the literature. Empirical specification that do not controlling for financial conditions and house prices are likely to retrieve dynamic responses that confound the effects of monetary policy shock with the endogenous response of the central bank to changes in the economy, leading the the well-known price and activity puzzles. Central to this result is that anything that effect on monetary policy and also has direct effect on real variables, and don't controlling for them, will create an endogenous component to the policy disturbances. In the remainder of the paper, I first describe in Section 2 the quantitative evidence that the FOMC consider financial condition and housing market stability in addition to the real forecasting variables which were typically expressed when the monetary authorities establish their decision-making for the Great Moderation period and discuss identification issues. I also explain the textual source data I compiled on FOMC meeting transcripts and how I measured the preference therein. In Section 3, I revisit the narrative identification proposed by Romer and Romer (2004) and derive an informationally-robust instrument to identify monetary policy shocks by including two important systematic components into their estimation framework. Section 3 presents two main econometric models I use to estimate impulse response functions of real economic variables to monetary policy shocks obtained in Section 2. Section 4 shows the main empirical findings based on the Local Projection and hybrid VARs. I offer concluding remarks in Section 5.

2 Discussion of FOMC Transcripts

This section proposes a new approach, text analysis, to estimating central bank preferences.

I extract a direct measure of the FOMC's preferences from publicly available transcripts. Below I outline the data sources used and describe how I quantified the preferences expressed in each FOMC meeting from 1991 to 2008. The key aspect of my findings from the the text analysis approach is that the FOMC considered credit spreads and housing prices significantly in addition to the real macroeconomic variables which were typically expressed such as real GDP, inflation, and the unemployment rate (and those forecasts) when the central bank established its monetary policy, especially during the Great Moderation period.

My main texture data source is the public archive of FOMC transcripts, which are the most detailed records of FOMC meeting proceedings, that can be obtained directly from the Federal Reserve Board of Governors website. Specifically, the FOMC Secretariat has produced the transcripts shortly after each meeting from an audio recording of the proceedings, lightly editing the speakers' original words to facilitate the reader's understanding. Meeting participants are given an opportunity within the subsequent several weeks to review the transcript for accuracy[3]. These include all regular FOMC meetings from 1976 to 2015, though I make use of February 1991 - December 2008 transcripts in this paper given other data constraints. Based on the data, my baseline sample is scheduled FOMC meeting days from February 1991 to December 2008. I do not use days with unscheduled meetings. The main reason for this is pragmatic: the test for the presence of systematic response of monetary policy to financial conditions and house prices in the following section uses the projections from the Greenbooks for the Federal Reserve Board of Governors. The Greenbook is produced only before each scheduled meeting of the Federal Open Market Committee so that it is not available for each unscheduled meeting day[4]. Hence, my samples are a total of 144 transcripts since the FOMC meeting were occurred 8 times a year[5].

In this paper, I provide a quantitative evidence for estimating central bank objectives. My

[3]For the meetings before 1994, the transcripts were produced from the original, raw transcripts in the FOMC Secretariat's files. Though these records have been lightly edited by the Secretariat to facilitate the reader's understanding, the errors undoubtedly remain since the raw transcripts were not fully edited for accuracy at the time they were prepared because they were intended only as an aid to the Secretariat in preparing meeting minutes. While it has been criticized whether it is appropriate to use the transcripts before 1994, to my knowledge it is the best data available to the public and sufficient to capture the FOMC's preferences.

[4]A potentially important concern relates to the role of unscheduled meetings, where the FOMC takes urgent decisions in moments of particular economic distress. These unexpected meetings may in fact be the ones responsible for the information channel, which discussed in Miranda-Agrippino and Ricco (2021). They address this concern by repeating the estimation using market surprises registered around scheduled FOMC meetings only and found that results are robust.

[5]My sample has 52 unscheduled meetings out of 196 total events from February 1991 to December 2008.

approach relies on the assumption that the central bank's preferences are embedded in the words spoken by central bank policy makers at internal meetings. Specifically, I demonstrate that the number of words expressed by policy makers can be used to directly measure the systematic components of monetary policy, including implicit inflation target, economic growth, financial market performance, and house prices. This approach could be used internally and externally to study the preferences of any central bank that has transcripts, statements, or detailed summaries of their policy making deliberations. I proceed in three steps. Initially, I convert the transcripts in pdf format to text files and then apply several filters to remove words likely to be especially noisy. Once a corpus, a collection of text documents, is created, then I modify the documents in it, e.g., stemming, stop-words and punctuation removal. First, I drop punctuations except inter-word dashes. Second, I remove extra white space and "stop-words", defined as a common word that usually has no analytic meaning in terms of English. Third, I reduce word forms to stems, which make any forms of a word to the primitive. In some cases, I wish to preserve a concept that is only apparent as a collection of two or more words, such as economic growth, inflation expectation, and house prices, then I combine them (or reduce them) to a meaningful acronym.

In the second step, I construct five different groups as a list of terms related to a specific economic variable. I used the Oxford Dictionary of Economics (ODE) to classify the key economic terms into several groups. In the meantime, after selecting and investigating some transcripts of the meeting, the FOMC members described which topic and how they were described it at each meeting, and based on this, word classification was carried out. I provide results based on the following five specifications: the first group that containing terms related to economic activities (named Output), the second group that containing terms related to labor, such as the unemployment rate or jobless, and the third group is composed of the terms that are related to inflation expectation, the fourth group is related to housing activities, and the last references to financial market performances[6]. Table 1 provides a list of words used in the transcripts by each group. The inflation terms are: inflation, inflation expectation, inflationary, inflationary expectation, deflation, deflationary, disinflation, disinflationary, consumer price, producer price, cpi, pce, and price stability. The output terms are: output, output gap, potential output, gdp,

[6]I follow Shapiro and Wilson's (2019) filtered subsets of transcript text for output, labor and inflation. For the lists of transcript text to housing and financial market performances, I use my own specification.

Table 1: List of words in each Group

Inflation	Output	Labor	Housing	Credit
			housing related	
inflation (expectation)	(potential) output (gap)		housing sector	
inflationary (expectation)	industrial production	natural rate	house (home) price	credit
deflation	(potential) gdp	unemployment	homeownership	credit spreads
disinflation	slack	employment	residential	treasuries
consumer prices	utilization	labor	mortgage	corporate bond
producer prices	recession	hire	fannie mae & freddie mac	yield curves
cpi & pce	economic activity	jobless	ofheo	forward rate
price stability	ecomonic growth		foreclosure	
			collateral	

potential gdp, industrial production, slack, utilization, recession, economic activity, and economic growth. The labor terms are as follows: unemployment, employment, labor, hire, jobless, and natural rate. In terms of housing, I use housing related, housing sector, house (home, housing) price, home-ownership, residential, mortgage, fannie mae, freddie mac, ofheo (Office of Federal Housing Enterprise Oversight), foreclosure, and collateral. For the terms related to credit market, I use credit, credit spreads, treasuries, corporate bond, yield curve, and forward rate.

Given a collection of text documents and categorization, in the last step, I calculate the total number of words stated for each group of transcript text. An important issue is that, as seen in Figure 1, the total word count for transcripts in each FOMC meeting increased over the sample period. The average length of the transcripts has risen from just under 11,000 words in 1991 to about 31,000 words in 2008. Accounting for that, I compute the share of a selected word counting in the total number of words stated, then I sum the share for every word listed in each group[7]. Table 2 provides the descriptive statistics from the text analysis. The results from this exercise have three key aspects of the conventional wisdom on FOMC preferences. The first relates to the inflation, and the second relates to preferences regarding economic activities and the unemployment rate. The third relates to housing activities and credit market performances. Beginning with the first aspect, the result indicates that the share or words contained in the inflation group have constituted about 1 percent on average of the total words over the sample period 1991 through 2008. Along with that, both the share of words contained in the output group and that in the

[7]For instance, the ratio of the selected words stated regarding inflation to total words in a given FOMC meeting can be computed as, $\frac{\#\ of\ words\ in\ Inflation\ group}{\#\ of\ total\ words} \times 100$

Table 2: Summary Statistics by Group, FOMC Transcripts, 1991 - 2008

Group	**Mean**	**SD**	**Min**	**Med**	**Max**
Output	0.520	0.150	0.219	0.504	0.879
Labor	0.510	0.218	0.170	0.478	1.117
Inflation	0.908	0.407	0.233	0.885	2.108
Housing	0.301	0.245	0.035	0.211	1.977
Credits	0.269	0.150	0.035	0.233	0.758
Total (#)	19431	7514	7329	17790	43401

labor group have constituted about 0.5 percent of the total words. These findings are consistent with the fact that the canonical model assumes that the central bank has quadratic preferences over inflation and economic activities (see Walsh (2017)). In contrast, the share of words contained in the group of housing price and credit have constituted around 0.3 percent of the total words on average, respectively, which are comparatively less than those in the inflation group and about 40 percent less than those of the Output-related and Labor-related words in each FOMC meeting all over the sample period.

I compare these results with those in Figure 2. Figure 2 shows how the share of the words for each group shift at each FOMC meeting from 1991 to 2008. The black-solid line shows the movement of share of word counts for output group, the black-dashed line shows that for labor group, and the blue-dotted line displays that for inflation group. The red-dashed line and green-solid line represent the share of words in Housing-Related group and Credit-Related group, respectively. The results form Table 2 and Figure 2 indicate two points. First, words related to inflation have been mentioned in a steady manner at each meeting at an average rate of 1 percent over the entire sample period. Similarly, words related to labor and output were found to have been expressed consistently at an average rate of 0.5 percent over the entire sample period. Interestingly, unlike inflation, labor, and output, the terms related to housing and credit vary in their frequency of used by members of FOMC over the sample period 1991 through 2008. Specifically, the period in which credit-related words were mentioned more than labor- and output-related words can be seen twice in the entire sample period, one at the FOMC meeting between 1998 and 2001 and the other in the middle of 2007 to the end of 2008, which is consistent with the findings from Peek et al. (2015), Walsh(2017), and Shapiro and Wilson (2019) who argue that the FOMC responds to financial variables. There is, in fact, considerable external support for this result. Thornton(2011) documents that from 1991 until 2009 the FOMC's policy directive, announced to the public after each FOMC meeting, stated "*The Federal Open Market Committee seeks monetary and financial conditions that will foster price stability and promote sustainable growth in output*". In both periods, indeed, the volatility of the financial market changed significantly[8]. The late 1990s was a period when the stability of the US financial market deteriorated significantly due to the rise and burst of IT bubble and the financial turmoil around the globe. On the other hand, in 2007, excessive risk-taking by banks, combined with the bursting of the U.S. housing bubble, caused the values of securities tied to U.S. real estate to plummet and damaged financial institutions. In common, FOMC participants recognized the serious volatility of financial markets at meetings during these two periods, and discussed to find ways to stabilize them. Below is the quote I found in the FOMC meeting transcript of November 17, 1998, in which a FOMC participant explicitly stated a preference for financial market stability.

> **The transcript of November 17, 1998, FOMC meeting:**
> Because of the recent financial market volatility, we made a special effort to contact some market participants at the Chicago futures and options exchanges. Although our contacts believe they have successfully weathered the extraordinary volatility of late summer and early fall, many were apprehensive about the market's ability to withstand future shocks. One concern is that market depth may suffer in the months ahead. ... Banks face pressure to get exposure off their books and consequently they have cancelled lines of credit to some clearing members. ... Financial markets have improved from their earlier unstable condition, but they are not yet back to normal. We need to continue to facilitate a return to normalcy. Financial markets currently are like a sick person who feels better after taking antibiotics for a few days but still needs to stay on medication to avoid a relapse and to aid a return to good health. ... Although conditions in financial markets have settled down materially since mid-October, unusual strains remain. With the 75 basis point decline in the federal funds rate since September, financial conditions can reasonably be expected to be consistent with fostering sustained economic expansion while keeping inflationary pressures subdued.

Second, as seen in Figure 2, the share of word counts for housing group increased dramatically after

[8] According to the Cboe Volatility Index (VIX), which is commonly known to measure the risk of financial markets, the period when the index exceeds 20 is in the late 1990s and after 2007.

2005. Until 2005, housing-related words had a steady share of about 0.2 percent of all transcripts. Beginning with the FOMC meeting in June 2005, the share of housing related words increased significantly, accounting for about 2 percent at this meeting. Given that the highest share of inflation-related words was 2.1 percent (October 2006), it can be seen that FOMC participants used the housing-related words unprecedentedly at the June 2005 meeting. From then on, housing-related words were spoken frequently, with an average 0.6 percent share from 2005 to 2008. Considering that the share of labor- and output-related terms since 2005 was 0.48 percent and 0.37 percent, respectively, this implies that the central bank has had a large preference over the housing-sector performances to their objective function for establishing monetary policy. Interestingly, the change in share of word counts for housing group is highly related to aggregate house price. Indeed, the rate of increase in real house prices (percent changes, based on month) has increased significantly since the early 2000s and peaked in November 2005. Notably, participants in the FOMC meeting in June 2005 have discussed this issue from various perspective. Particularly, they tried find out what model could be the best capturing the macroeconomic implications of changes in house prices. The following is the quote I found in the FOMC meeting transcript of June 30, 2005, in which some FOMC participants explicitly stated a performance for housing market.

> **The transcript of June 30, 2005, FOMC meeting:**
>
> *MR.GALLIN.* House prices, adjusted for general in ation, have risen at a rapid pace in recent years and did not even pause during the last recession. Indeed, the real rate of appreciation has increased, and the most recent readings have been at annual rates greater than 7 percent. By comparison, the average annual increase in real house prices during the past 30 years is only about 1.75 percent. ...
>
> *MR. LEHNERT.* The popular consensus appears to be that homebuyers, especially in hot housing markets, now make token down payments and can just scrape into their homes by resorting to interest-only mortgages; in this view, borrowers and lenders alike are vulnerable to any fall in house prices. In my prepared remarks I will address each of these issues.
>
> *MR. WILLIAMS.* I'll lay out a few scenarios that illustrate the potential macroeconomic fallout resulting from a significant decline in house prices, and I will examine policy responses that minimize it. ...
>
> *MS. YELLEN.* A second comment I wanted to make concerns the relationship of creative finance to the housing market. One view that I think is very prevalent is that the use of

> credit in the form of piggyback loans, interest-only mortgages, option ARMs [adjustable-rate mortgages], and so forth, involves financial innovations that are feeding a kind of unsustainable bubble. But an alternative perspective on that is that high house prices, in fact, are curtailing effective demand for housing at this point and that house appreciation probably is poised to slow. So the increasing use of creative financing could be a sign of the final gasps of house-price appreciation at the pace we've seen and an indication that a slowing is at hand.

The results of section 2 suggest two aspects; first, by measuring the central bank's preference in transcripts of each FOMC meeting over the period 1991 through 2008 directly by using text analysis, I suggest that the house prices and credit spreads have had consistent and non-negligible effects on the central bank's monetary policy decision making (in the point of narrative approach) along with inflation and economic growth, which can imply that those are the important parts of the central bank's objective function. Second, in contrast with conventional wisdom, identification of the objective function in Monetary authority without accounting for the endogenous reactions induced by the financial and housing market would have confounding effects of monetary policy on the real economy, especially for the Great Moderation period. Apparently, this quantitative exercise is more obvious when compared to the numerical evidence. In the next section, to see whether monetary policy systematically responds to house prices and credit spreads, I re-build the series of new monetary policy shocks with two changes to Romer and Romer's (1989, 2004) equation estimation framework.

3 Policy Surprises

Previous section provided a quantitative result to establish the presence of interdependences between monetary policy and changes in economic conditions, especially credit market performances and house prices. In this section, I build on this result to re-examine the narrative identification of monetary policy shocks of Romer and Romer (2004). Specifically, I first document that the R&R shocks contain the systematic response of monetary policy to corporate credit spreads. Next, I construct the R&R shocks including another systematic response of monetary policy to house prices. I then finally define monetary policy shocks as shift to the policy rate that are exogenous to changes in economic conditions, corporate credit spreads, and house prices. Hence, building on Romer and Romer (2004)'s identification, I propose a new instrument for monetary policy shocks that take into account both the systematic components, credit spreads and house prices in the function of policy making. At the end of this section, I show the implications of this finding by comparing the quantitative result that I provided in the previous section.

In general, narrative approaches involve constructing a series from historical documents to identify the reason and/or the quantities associated with a particular change in a variable. Romer and Romer (2004) proposed to identify monetary policy shocks by using the real-time "Greenbook" forecasts prepared by the Federal Reserve's economic staff in advance of each FOMC meeting. Greenbook forecasts have the appeal of being the actual figures and numbers discussed by the FOMC members at the meeting. Importantly, because the Greenbook forecasts are prepared prior to when the FOMC meets, they can be considered exgeneous with respect to the committee's dialogue. Following Romer and Romer (2004), Coibion and Gorodnichenko (2011), and others, my baseline estimation specification is constructed by regressing intended Federal Funds rate change Δff_m decided at FOMC meeting date (m), on Greenbook forecasts to control for current economic conditions and the future economic outlook, especially on the level of, and the revisions to, the Federal Reserve's forecasts of real GDP growth, the unemployment gap, and inflation. Greenbook forecasts are available from the Federal Reserve Bank of Philadelphia[9]. These forecasts are typically published a week prior to each scheduled FOMC meeting and can be thought of as a proxy of the information set of the FOMC at the time of making the policy decision. For Δff_m, I update the series of intended federal funds changes to the end of 2008[10]. I first estimate the original form of regression equation by Romer and Romer (2004) as following:

$$\begin{aligned}\Delta ff_m = \alpha + \beta ffb_m + \sum_{i=-1}^{2}\Big[\gamma_i \Delta\tilde{y}_{m,i}\Big] + \sum_{i=-1}^{2}\Big[\phi_i \tilde{\pi}_{m,i}\Big] + \sum_{i=-1}^{2}\Big[\lambda_i(\Delta\tilde{y}_{m,i} - \Delta\tilde{y}_{m-1,i})\Big] \\ + \sum_{i=-1}^{2}\Big[\theta_i(\tilde{\pi}_{m,i} - \tilde{\pi}_{m-1,i})\Big] + \rho\tilde{u}_{m,0} + \varepsilon_m^{(1)} \qquad (1)\end{aligned}$$

where m is the monthly date of scheduled FOMC meeting, Δff_m is the changes in intended target

[9]See URL: https://www.philadelphiafed.org/surveys-and-data/real-time-data-research/philadelphia-data-set

[10]While Greenbook forecast are available until the end of 2015 (as of the time of this writing), the interest rates approached the zero lower bound from 2009 onwards so that the regression including the sample period after 2009 might not appropriately capture the Federal Reserve's intended rates of policy target.

rate at meeting m[11], ffb_m is the level level of intended target rate before any policy decision associated with meeting m; $\tilde{u}$, $\tilde{y}$, and $\tilde{\pi}$ are the Greenbook forecasts of the unemployment rate, the real GDP growth, and inflation, respectively (prior to the choice of the interest rate); and the i index in the summations refers to the horizon of the forecasts. The regression includes both the level of the output and inflation forecasts and the revision from the previous meeting. The estimated residuals $\hat{\varepsilon}_m^{(1)}$ are interpreted as policy innovations at FOMC meeting frequency.

Next, I reconstruct the RR shocks with three changes to their estimation framework. First, I include in the regression an indicator of credit spreads, I then estimate the following equation:

$$\Delta ff_m = \alpha + \beta ffb_m + \delta cs_m^{5d} + \sum_{i=-1}^{2}\left[\gamma_i \Delta\tilde{y}_{m,i}\right] + \sum_{i=-1}^{2}\left[\phi_i \tilde{\pi}_{m,i}\right] + \sum_{i=-1}^{2}\left[\lambda_i(\Delta\tilde{y}_{m,i} - \Delta\tilde{y}_{m-1,i})\right] + \sum_{i=-1}^{2}\left[\theta_i(\tilde{\pi}_{m,i} - \tilde{\pi}_{m-1,i})\right] + \rho\tilde{u}_{m,0} + \varepsilon_m^{(2)} \quad (2)$$

Because Greenbook forecasts for credit spreads are available only starting in 1998, my instrument is instead cs_m^{5d}, the average Baa spread for the five days prior to the FOMC meeting[12]. I denote the associated regression coefficient by δ. The equation (2) delivers a residual as an instrument for monetary policy shocks, $\hat{\varepsilon}_m^{(2)}$, at meeting frequency that controls for the central bank's private information related to credit market performances. Second, I add only the house price indicator to the existing baseline regression equation. Since forecasts for house prices are not provided in the Greenbook[13], my instrument is instead Δh_m, the differences in the log of real house price index[14] at meeting m. The monthly information of house prices is only available after January 1991, so that my sample period is from January 1991 to December 2008. I run the following regression at

[11] To match the dates of the Greenbook forecast with FOMC meetings I develop FOMC dates which are available from the Board of Governors of the Federal Reserve System.

[12] Results are robust to using the average Baa spread calculated from the first day of the month when the FOMC meeting takes place to the day prior to the meeting.

[13] While Greenbook forecasts for house prices had been firstly introduced in March 2006 meeting in the graphically way based on the staff projection (Figure 3), the numerical data are not yet available to the public.

[14] The housing price index (HPI) is published by the FHFA (Federal Housing Finance Agency), and measures changes in the value of single-family homes. The HPI is a weighted repeat sales index: it measures average price changes in repeat sales or refinancings on the same properties and weights them. The price information is obtained from repeat mortgage transactions on single-family properties whose mortgages have been purchased or securitized by Fannie Mae or Freddie Mac since January 1975. I compute growth rates using log-differences in a monthly-basis, in percent. Since the HPI data are nominal, I deflate the data using headline CPI inflation.

FOMC meeting frequency.

$$
\begin{aligned}
\Delta ff_m = \alpha + \beta ffb_m &+ \sum_{j=2}^{4}\Big[\psi_j L^j \Delta h_m\Big] + \sum_{i=-1}^{2}\Big[\gamma_i \Delta\tilde{y}_{m,i}\Big] \\
&+ \sum_{i=-1}^{2}\Big[\lambda_i(\Delta\tilde{y}_{m,i} - \Delta\tilde{y}_{m-1,i})\Big] + \sum_{i=-1}^{2}\Big[\phi_i \tilde{\pi}_{m,i}\Big] \\
&+ \sum_{i=-1}^{2}\Big[\theta_i(\tilde{\pi}_{m,i} - \tilde{\pi}_{m-1,i})\Big] + \rho\tilde{u}_{m,0} + \varepsilon_m^{(3)}
\end{aligned} \tag{3}
$$

I note here that the house price data releases with a lag of 2 or 3 months. For instance, the FHFA released its HPI report for November 2020 on January 26, 2021, and the data for January 2021 on March 30, 2021. As a result, the most recent monetary authority information set contains information on house prices about two or three months ago. This can be found in more detail (as can be seen in Figure 3) by looking at the transcripts and Greenbook forecasts of the each FOMC meeting. To address this concern, I include in the equation the rate of change in real house prices for the 2-month, 3-month and 4-month prior to the meeting date[15]. I denote the associated regression coefficients by ψ_j. This step provides a residual as an instrument for monetary policy shocks, $\hat{\varepsilon}_m^{(3)}$, at meeting frequency that controls for the information related to house prices. Next, I include both indicator of credit spreads and house prices into the baseline regression equation. I estimate the regression specified as following:

$$
\begin{aligned}
\Delta ff_m = \alpha + \beta ffb_m + \delta_{cs} cs_m^{5d} &+ \sum_{j=2}^{4}\Big[\psi_j L^j \Delta h_m\Big] + \sum_{i=-1}^{2}\Big[\gamma_i \Delta\tilde{y}_{m,i}\Big] \\
&+ \sum_{i=-1}^{2}\Big[\lambda_i(\Delta\tilde{y}_{m,i} - \Delta\tilde{y}_{m-1,i})\Big] + \sum_{i=-1}^{2}\Big[\phi_i \tilde{\pi}_{m,i}\Big] \\
&+ \sum_{i=-1}^{2}\Big[\theta_i(\tilde{\pi}_{m,i} - \tilde{\pi}_{m-1,i})\Big] + \rho\tilde{u}_{m,0} + \varepsilon_m^{(4)}
\end{aligned} \tag{4}
$$

According to the equation (4), I finally construct monetary policy shocks as shifts to the policy rate, $\varepsilon_m^{(4)}$, that controls for the central bank's concern regarding credit markets and house prices at the time of FOMC meeting. Lastly, I build the four series of monthly policy surprises[16] as an external instrument to identify the monetary policy shock, based on the estimation residuals from

[15]Results are robust to using the rate of change in real house prices two months ago or three months ago only.

[16]Months without FOMC meetings are assigned a zero.

equation (1) through equation (4).

The first column [1] of Table 3 tabulates the estimated coefficients and relative significance level of the projection of the changes in the intended funds rate over Greenbook forecasts and revisions to forecasts for output, in inflation and unemployment. The regression is run at monthly frequency on all surprises registered between 1991 and 2008. I do not include the zero-lower bound (ZLB) period because there is no time variation in the federal funds rate. The result suggests that output and inflation forecasts has significant and positive coefficients. Moreover, the unemployment forecasts have significant and negative coefficient. In line with the results reported in Romer and Romer (2004) and Coibion and Gorodnichenko (2011), the estimates show that monetary policy tends to behave counter-cyclically and stabilizes movements in output and inflation. The R^2 of the regression is 0.51 , suggesting that although most of the changes in US monetary policy were taken in response to the evolution of forecasted output, unemployment and inflation, it does not guarantee that the unexplained variation is exogenous to the state of the economy. The second column [2] of Table 3 tabulates the estimated coefficients for a regression that includes corporate credit spreads. The estimated coefficients of the changes in the intended funds rate over Greenbook forecasts and revisions are similar to that in the fist column [1]. Notably, I find that the central bank reacts to changes in the Baa spread beyond the information contained in the Greenbook forecast of output, unemployment and inflation. δ has a point estimate of -0.16 with a small standard error; all else being equal, FOMC meetings occurring in periods with elevated levels of corporate credit spreads are associated with cuts in the intended federal funds rate. This evidence shows that, for the 1991–2008 period, the standard estimates of the R&R shocks are affected by the endogenous response of monetary policy to changes in credit spreads[17]. The third column [3] of table 3 reports the estimated coefficients for a regression equation (3) that includes three lags of log-differences in real house prices. For robustness (multicollinearity), in columns [3-1] to [3-3] I evaluate the content of passed information by each lag. As it can be seen that the estimated coefficients of the changes in the intended funds rate over Greenbook forecasts and revisions are consistent with the results shown in column [1] and [2]. Moreover, I find that the U.S. monetary authority had systematically responded to changes in real house prices by weighting them with positive values for the 1991-2008

[17]This evidence is consistent with Peek, Rosengren, and Tootell (2016), who use textual analysis to examine FOMC transcripts and find that, even after controlling for forecasts of inflation and unemployment, the word counts of terms related to financial conditions predict monetary policy decisions.

Table 3: Determinants of the Change in the Intended Federal Funds Rate

	[1]	[2]	[3]	[3-1]	[3-2]	[3-3]	[4]	[4-1]	[4-2]	[4-3]
Old Target	-0.0732***	-0.109***	-0.0949***	-0.0854***	-0.0925***	-0.0895***	-0.118***	-0.114***	-0.115***	-0.115***
	[0.0213]	[0.0220]	[0.0224]	[0.0218]	[0.0225]	[0.0212]	[0.0231]	[0.0225]	[0.0230]	[0.0221]
Credit Spreads		-0.162***					-0.128***	-0.144***	-0.127***	-0.133***
		[0.0394]					[0.0371]	[0.0368]	[0.0379]	[0.0368]
House Prices										
L = 2			0.0403	0.119*			0.0517	0.100		
			[0.0564]	[0.0640]			[0.0556]	[0.0615]		
L = 3			0.0634		0.152**		0.0228		0.114*	
			[0.0647]		[0.0658]		[0.0690]		[0.0658]	
L = 4			0.108*			0.170***	0.0978			0.137**
			[0.0551]			[0.0596]	[0.0606]			[0.0601]
Forecasts										
Unemployment										
h = 0	-0.0760**	-0.101***	-0.0941***	-0.0888***	-0.0989***	-0.0850***	-0.107***	-0.107***	-0.112***	-0.103***
	[0.0319]	[0.0294]	[0.0316]	[0.0319]	[0.0319]	[0.0309]	[0.0301]	[0.0302]	[0.0301]	[0.0294]
Output										
h = -1	0.0366**	0.0221	0.0444***	0.0372**	0.0433***	0.0416**	0.0316*	0.0244*	0.0302*	0.0296*
	[0.0156]	[0.0139]	[0.0165]	[0.0159]	[0.0163]	[0.0160]	[0.0160]	[0.0147]	[0.0158]	[0.0151]
h = 0	0.0735***	0.0603***	0.0698***	0.0714***	0.0686***	0.0737***	0.0625***	0.0615***	0.0612**	0.0648***
	[0.0219]	[0.0222]	[0.0243]	[0.0234]	[0.0243]	[0.0231]	[0.0236]	[0.0233]	[0.0239]	[0.0225]
h = 1	0.0216	0.00487	0.00273	0.0140	0.0104	0.00771	-0.00909	-0.00131	-0.000912	-0.00559
	[0.0243]	[0.0250]	[0.0265]	[0.0252]	[0.0228]	[0.0271]	[0.0279]	[0.0261]	[0.0241]	[0.0281]
h = 2	0.0172	0.0146	-0.00625	0.00522	0.00178	-0.00637	-0.00503	0.00392	0.00228	-0.00491
	[0.0269]	[0.0265]	[0.0261]	[0.0258]	[0.0239]	[0.0276]	[0.0261]	[0.0255]	[0.0243]	[0.0269]
Inflation										
h = -1	0.0257	0.0194	0.0341	0.0290	0.0396*	0.0317	0.0260	0.0238	0.0324	0.0257
	[0.0209]	[0.0204]	[0.0223]	[0.0211]	[0.0216]	[0.0213]	[0.0218]	[0.0206]	[0.0213]	[0.0211]
h = 0	0.0359	0.0427*	0.0551*	0.0492*	0.0524*	0.0494*	0.0546**	0.0511*	0.0519*	0.0504*
	[0.0273]	[0.0254]	[0.0282]	[0.0269]	[0.0295]	[0.0273]	[0.0273]	[0.0264]	[0.0283]	[0.0271]
h = 1	0.0688	0.0632	0.0826	0.0790	0.0975	0.0811	0.0697	0.0709	0.0866	0.0718
	[0.0693]	[0.0651]	[0.0706]	[0.0697]	[0.0662]	[0.0700]	[0.0701]	[0.0675]	[0.0649]	[0.0685]
h = 2	0.167**	0.126*	0.225**	0.202**	0.199***	0.204**	0.183**	0.158*	0.155**	0.162**
	[0.0738]	[0.0725]	[0.0865]	[0.0826]	[0.0760]	[0.0792]	[0.0870]	[0.0815]	[0.0762]	[0.0802]
Forecasts Revisions										
Output										
h = -1	-0.0256	-0.0141	-0.0194	-0.0178	-0.0272	-0.0149	-0.0103	-0.00900	-0.0175	-0.00839
	[0.0271]	[0.0250]	[0.0263]	[0.0256]	[0.0268]	[0.0259]	[0.0261]	[0.0242]	[0.0261]	[0.0247]
h = 0	0.0145	-0.00414	0.0193	0.0150	0.0186	0.0139	0.00318	-0.00250	0.00158	-0.00123
	[0.0321]	[0.0298]	[0.0336]	[0.0324]	[0.0335]	[0.0325]	[0.0326]	[0.0306]	[0.0324]	[0.0312]
h = 1	0.0563	0.0510	0.0643*	0.0683*	0.0647*	0.0604	0.0601	0.0638*	0.0605*	0.0563
	[0.0366]	[0.0338]	[0.0378]	[0.0387]	[0.0351]	[0.0387]	[0.0367]	[0.0366]	[0.0344]	[0.0366]
h = 2	0.0411	0.0110	0.0195	0.0362	0.0270	0.0147	-0.00111	0.00828	0.00456	-0.00647
	[0.0610]	[0.0567]	[0.0562]	[0.0585]	[0.0550]	[0.0610]	[0.0545]	[0.0543]	[0.0536]	[0.0582]
Inflation										
h = -1	-0.0310	-0.0361	-0.0344	-0.0333	-0.0389	-0.0369	-0.0383	-0.0365	-0.0419	-0.0417
	[0.0545]	[0.0495]	[0.0454]	[0.0452]	[0.0460]	[0.0494]	[0.0437]	[0.0420]	[0.0448]	[0.0468]
h = 0	-0.0466	-0.0622*	-0.0687**	-0.0506*	-0.0700**	-0.0665**	-0.0724***	-0.0625**	-0.0754**	-0.0735***
	[0.0288]	[0.0315]	[0.0275]	[0.0264]	[0.0279]	[0.0258]	[0.0275]	[0.0274]	[0.0290]	[0.0271]
h = 1	0.000661	0.00501	0.0222	-0.000622	0.00336	0.0169	0.0265	0.00680	0.00678	0.0216
	[0.0944]	[0.0880]	[0.0985]	[0.0970]	[0.0925]	[0.0975]	[0.0975]	[0.0934]	[0.0907]	[0.0959]
h = 2	-0.0623	-0.0515	-0.0926	-0.0547	-0.0642	-0.0885	-0.0788	-0.0465	-0.0513	-0.0741
	[0.115]	[0.107]	[0.116]	[0.115]	[0.113]	[0.115]	[0.112]	[0.110]	[0.110]	[0.111]
Constant	-0.302	0.540**	-0.242	-0.266	-0.236	-0.263	0.406*	0.475**	0.410*	0.422*
	[0.184]	[0.217]	[0.170]	[0.170]	[0.168]	[0.174]	[0.225]	[0.215]	[0.229]	[0.221]
Observations	144	144	141	142	142	141	141	142	142	141
R-squared	0.515	0.566	0.569	0.547	0.561	0.565	0.598	0.587	0.589	0.598

Note: Projection of Δff_m , the series of changes in the intended funds rate around FOMC meetings constructed using the methodology in Romer and Romer (2004) on Greenbook Forecasts (revisions), corporate credit spreads, and house prices in the sample 1991:2008. Robust standard errors in brackets. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$. Details on the specifications are reported in the text.

period. ψ_j have a point estimate of the range in 0.1 and 0.17 with a small standard error; all else being equal, FOMC meetings occurring in the period with elevated levels of house price growth are associated with rising in the intended federal funds rate. Lastly, the column [4] in table 3 shows the estimation result using equation (4) that contains both average Baa credit spreads and three lags of changes in real house prices. Similarly to column [3-1] to [3-3], I evaluate the content of passed information of house prices by each lag, from [4-1] to [4-3], respectively. In line with the previous results reported in column [1] to [3], the estimated coefficients provide the evidence that monetary authority tends to endogenously response to the current economic condition and its outlooks (output, unemployment, and inflation forecasts (and those revisions). Besides, the standard estimates of the R&R shocks are affected by the endogenous response of monetary policy to changes in credit spreads and house price growths, simultaneously. The residuals of the four regressions shown in Table 3 constitute narrative-based measures of shocks. Here, I denote the shocks constructed using regression equation (1): "RR", the shocks constructed using regression equation (2): "RR-CS", the shocks constructed using regression equation (3): "RR-HP", and the shocks constructed using regression equation (4): "RR-CS-HP". Though the shocks are highly correlated (0.91 on average) each other, but they lead to dramatically different implications about monetary policy, as I show in the next section.

Taking stock of these numerical evidences, in the next I empirically document two testable implications from the results of text analysis using FOMC transcripts discussed in the section 2. In particular, Figure 4 reports the test for correlation with the share of the word counts in the credit group (a set of list that contains terms related credit market performances) and the numerical differences that can be occurred if changes in corporate spreads are not taken into account when constructing R&R shocks. Similarly, Figure 5 reports the correlation with the share of the word counts in the housing group (a set of list that contains terms related housing market) and the numerical differences that can be occurred if changes in house prices are not taken into account when constructing R&R shocks.

I proceed in two steps. First, I construct two indexes to show the numerical differences caused by credit spreads from the residuals of the regressions shown in Table 3 applying simple euclidean distance formula. I use the following specification:

$$D[RR,\ RR\text{-}CS] = \sqrt{([RR] - [RR\text{-}CS])^2} * 100 \tag{5}$$

$$D[RR\text{-}HP,\ RR\text{-}CS\text{-}HP] = \sqrt{([RR\text{-}HP] - [RR\text{-}CS\text{-}HP])^2} * 100 \tag{6}$$

where “RR” is the shocks constructed using regression equation (1), “RR-CS” is the shocks constructed using regression equation (2), “RR-HP” is the shocks constructed using regression equation (3), and “RR-CS-HP” is the shocks constructed using regression equation (4). To make the comparison easier, the difference is rescaled by multiplying 100. Next, in a same manner, I build other two indexes to imply the numerical differences caused by house prices from the residuals of the regressions shown in Table 3. Specifically:

$$D[RR,\ RR\text{-}HP] = \sqrt{([RR] - [RR\text{-}HP])^2} * 100 \tag{7}$$

$$D[RR\text{-}CS,\ RR\text{-}CS\text{-}HP] = \sqrt{([RR\text{-}CS] - [RR\text{-}CS\text{-}HP])^2} * 100 \tag{8}$$

In summary, the equation (5) and (6) imply the distances of the R&R shocks which were caused whether it controls the corporate credit spreads or not, and the equation (7) and (8) imply the distances of the R&R shocks which were originated by house prices for their shock construction.

Time series plots of the results from text analysis in Section 2 and the distances in the baseline R&R shocks with alternative identifications, in terms of credit markets and housing market, are provided in Figure 4 and Figure 5, respectively. The shaded bars in Figure 4 depicts the share of word counts related to credit market performances to the total words expressed for transcripts in each FOMC meeting from July 1991 to December 2008, which is the same component with green-solid line plotted in Figure 2. The black dashed line, *D[RR, RR-CS]*, refers to re-scaled euclidean distances between the “RR” and “RR-CS” and the blue solid line, *D[RR-HP, RR-CS-HP]*, shows the differences between the “RR-HP” and “RR-CS-HP”. Notably, I document that the values of both distance indexes are caused when it does not control for the endogenous response of monetary policy to corporate spreads. Two remarkable results can be found in Figure 4. First, the figures of the two distance indexes are very similar to each other over the sample period, and the second is that the two distance indexes and the result of the text analysis related to the credit spread in Section 2 have a higher relationship. The correlation, indeed, between CR and those distances are around 0.4 to 0.45. This implies that the quantitative analysis using the FOMC transcripts are consistent with the numerical results estimated through the re-constructed Romer and Romer (2004) equation. Thus, the quantitative and numerical approaches provide the empirical evidence that, for the Great Moderation period, the effects of monetary policy shocks depends on the presence of a systematic response of monetary policy to financial performances. Interestingly, I find another important systematic component that can be economically significant in the information set of the monetary authority, as can be seen in Figure 5. The shaded bars in Figure 5 depicts the share of word counts related to housing markets to the total words expressed for transcripts in each FOMC meeting, which is the same component with red dashed line plotted in Figure 2. The black dashed line, *D[RR, RR-HP]*, refers to re-scaled euclidean distances between the "RR" and "RR-HP" and the blue solid line, *D[RR-CS, RR-CS-HP]*, shows the differences between the "RR-HP" and "RR-CS-HP". Again, I argue that the values of both distance indexes are caused when it does not control for the endogenous response of monetary policy to house prices. Similarly, the one of distance index moves along with other distance index for the given sample period. Moreover, the two distance indexes and the result of the textual analysis related to the housing prices have a higher relationship. The correlation between HR and those distances are around 0.34 to 0.4. Hence, the results provide another important evidence that a systematic component of monetary policy characterized by a direct reaction to changes in house prices.

The most important implication of the analysis presented in the section is that house prices and corporate credit spreads are important variables in the preference set of the monetary authority to characterize the transmission of monetary policy given quantitative and numerical evidence. It is fact that anything that effect on monetary policy and also has direct effect on real economic variables, and don't controlling for that, will create an endogenous component to the monetary policy shocks. In turn, the failure to account for these systematic reactions induces an attenuation in the response of all real variables to monetary policy shocks. In the following section, I introduce an econometric estimation method to study how the failure accounting for credit spreads and house prices actually induces a bias in the response of real variables to the monetary policy shocks.

4 Econometric Methodology

In conventional wisdom, the study of dynamic causal inference of monetary policy can be analysed into two steps. The first would be the step identifying exogenous (and unexpected) variation in monetary policy, which I discussed in the Section 3, and the second step delivers the impulse response functions estimated with given shocks from the first step. In this section, I first document a structural Vector Autoregressive (SVAR) model and derive the standard monetary policy rule embedded in the SVAR and its restrictions. To adjust this concern, I then present the alternative methodology. I show the implications of the RR shocks contained the systematic response of monetary policy to corporate credit spreads, house prices, or both by estimating the direct regression method, Local Projection (LP) by Jordà (2005). I describe the dataset that I used for the estimation. For further expansion, I discuss the evidence from using hybrid VAR specification - models that are typically used to track the effects of policy shocks using external instruments - in order to show the consistent results.

- The standard SVAR Model

Consider the following VAR, written in structural form:

$$A_0 y_t = \sum_{\ell=1}^{p} A_\ell y_{t-\ell} + c + e_t = A_+ x_t + e_t, \qquad for \quad 1 \leq t \leq T, \tag{9}$$

where y_t is a $n \times 1$ vector of endogenous variables, e_t is $n \times 1$ vector of structural shocks, A_ℓ is an $n \times n$ matrix of structural parameters for $0 \leq \ell \leq p$, c is a $n \times 1$ vector of intercepts, p is the lag length, T is the sample size, $x_t = [y_{t-1}^{'} \cdots y_{t-p}^{'} \; 1]^{'}$, and $A_+ = [A_1 \cdots A_p \; c]$. The reduced-form representation of this model is given by

$$y_t = \Phi x_t + u_t, \qquad u_t \sim N(0, \Sigma) \tag{10}$$

where the reduced-form parameters and the structural parameters are related through

$$\Sigma = (A_0^{'} A_0)^{-1} \qquad and \qquad \Phi = A_0^{-1} A_+ \tag{11}$$

As discussed in Leeper, Sims, and Zha (1996), specifying the monetary policy shock, denoted $e_{mp,t}$, is equivalent to specifying an equation that characterizes monetary policy behaviour. In what follows, I assume, without loss of generality, that $e_{mp,t}$ is the first shock in e_t. Consequently, the first equation of the SVAR is the monetary policy equation, for $1 \leq t \leq T$,

$$A_{0,1} y_t = A_{+,1} x_t + e_{mp,t} \tag{12}$$

where $A_{0,1}$ and $A_{+,1}$ denote the first row of A_0 and A_+, respectively. If we assume that the policy rate r_t is also ordered first in y_t, I can rewrite equation (12) as follows: For $1 \leq t \leq T$

$$r_t = \sum_{j=2}^{n} y_{j,t}^{'} \ \psi_{0,j} + \sum_{\ell}^{p} y_{t-\ell}^{'} \ \psi_\ell + \ \sigma_{mp} e_{mp,t} \tag{13}$$

where $\psi_{0,j} = -a_{0,1j}/a_{0,11}$, $\psi_\ell = a_{\ell,1\cdot}/a_{0,11}$, and $\sigma_{MP} = 1/a_{0,11}$ with $a_{\ell,ij}$ denoting ijth element of A_ℓ. The first two terms on the right-hand side of equation (13) describe the systematic component of monetary policy (in the central bank's information set), characterizing how the policy rate at time t responds to contemporaneous and lagged movements in the variables included in the model.

It is clear from equations (12) and (13) that the identification of the monetary policy shock $e_{mp,t}$ is equivalent to the identification of the systematic component of monetary policy. In turn, to characterize that we require knowledge of a subset of the structural parameters, $A_{0,1}$ and $A_{+,1}$. As is well known, without additional restrictions, it is not possible to discriminate between the many possible combinations of structural parameters $(A_{0,1},\ A_{+,1})$ that yield the same reduced-form parameters $(\Sigma,\ \Phi)$, that is, the likelihood of the SVAR model (9) is at with respect to these combinations. If the VAR adequately captures the components in the information set of monetary authority, this method is optimal at all horizons. The majority of the literature, beginning with Sims (1980) and discussed in CEE(1999); Stock and Watson (2001), has used theoretical restrictions to achieve identification, that is, to inform the choice of $(A_{0,1},\ A_{+,1})$, and most debates in the SVAR literature are about the "correct" choice of restrictions for any given application. In turn, if the VAR is misspecified, then the specification errors will be compounded at each horizon. By contrast, in this paper, I follow a different strategy, which I discuss next.

- Local Projections

Based on the four series of residuals from the regressions shown in Table 3, I estimate the specified macroeconomic variables directly to at horizon $t + h$ on the shock in period t, as constructing impulse responses with Local Projection method as described in Jordà (2005). The advantage of this method is that impulse responses are not functions of the structural parameters of the standard Vector Autoregressive (VAR) model, and hence are less sensitive to model misspecification. Moreover, Ramey (2016) shows that the use of local projections, as opposed to VAR models, can have a major impact on the sign and size of impulse responses to a monetary policy shock. To investigate the results of this less restrictive specification, I estimate the following series of regressions: For each $h = 0, 1, ..., H$,

$$y_{j,t+h} = \alpha_h + \beta_{j,h} e_{i,t} + \psi_{j,h}(L) z_t + \varepsilon_{j,t+h} \tag{14}$$

where y_j is the variable of interest, z is a vector of (pre-treatment) control variables, $\psi_{j,h}(L)$ is a polynomial in the lag operator, and $e_{i,t}$ is the identified monetary shock which I discussed in the previous section, "RR", "RR-CS", "RR-HP", and "RR-CS-HP". The coefficient $\beta_{j,h}$ gives the response of y_j at time $t + h$ to the shocks at time t. Thus, one constructs the impulse responses as a sequence of the $\beta_{j,h}$s estimated in a series of single regressions for each horizon.

In this exercise, the vector of endogenous variables, y, consists of the real industrial production (IP), the unemployment rate, consumer price index (CPI), real durable/non-durable consumption indexes, real house price index[18], an average 10-Year Baa corporate credit spread, and the federal funds rate[19]. Variables enter the specification in log levels with the exception of interest rates and credit spreads. By keeping the composition of variables of interest fixed across the four alternative estimation models, I can interpret the differences in the IRFs as an indication of the shocks constructed under different identification. The estimation is run on a monthly basis for the sample period January 1991 through December 2008. The term $\psi(L)$ is a polynomial of order 6[20]. The vector of (pre-treatment) control variables, z, contains six lags of interest rates, log of industrial productions, the unemployment rates, log of prices, log of durable and non-durable consumptions,

[18] I deflate the price information using consumer price index for all items in U.S. city average since the index is measured in nominal basis.

[19] My sample period does not include the zero lower bound.

[20] The estimation results are robust including contemporaneous value of control variables to preserve the recursiveness assumption.

log of commodity prices, and 1-year treasury constant maturity rates. Most of the data can be obtained from Federal Reserve Bank of St Louis database (FRED) and Federal Housing Finance Agency (FHFA). As described in Silvia and Giovanni (2019), ε_{t+h} will be serially correlated, so the standard errors must incorporate a correction, such as Newey-West.

- Estimation of Structural IRFs using external Instruments, Hybrid-SVARs

As discussed in section 3, the residuals of the four regressions shown in Table 3 constitute narrative-based measures of shocks. The Hybrid-SVARs specification substitutes the narrative (and cumulative) shocks for the federal funds rate (ordered last) in a standard VARs model, as shown in Coibion (2012), Barakchian and Crowe(2013), and Ramey (2016). In my explorations, I use the Coibion version of the Hybrid VAR, a monthly VAR with the fixed composition of variables, to trace the effects of each identified monetary shock but the cumulative shocks constructed in Section 3 replace the federal funds rate in the estimation system. This specification uses the recursiveness assumption as well, placing the funds rate last in the ordering and thus assuming that the monetary shock cannot have an impact on the macroeconomic variables within the month.

5 The Dynamic Causal Inference of Monetary Policy

In this section, I trace the implications of the different content of alternative instruments for the identification of monetary policy shocks. To show how monetary policy, real activity, credit spreads, and house prices interact through the Local Projections, I present results from four sets of models. I first estimate the equation (14) described in the previous section with the identified monetary shock, $e_{1,t}$, which constructed without controlling for the response of monetary policy to both credit spreads and house prices. The second set controls for seasoned Baa corporate bond yield relative to the yield on ten-year treasury constant maturity, which I refer to as the credit spread by setting $e_{2,t}$ to be the RR-CS shock. I then compare the dynamic causal inferences with the two specifications. The similar process will be applied for the model related to house prices. In this model of regression I set $e_{3,t}$ to be the RR-HP shock. The last set controls for both credit spread as well as house prices by setting $e_{4,t}$ to be the RR-CS-HP shock. Then I compare the dynamic responses across all instruments. In line with what I discussed in the section 3, the results of this analysis can reveal contamination of the policy instruments by the endogenous components to monetary shocks. To further corroborate the importance of controlling for the systematic components when using the narrative shocks, I construct impulse responses with Hybrid-VARs[21].

- Results from Local Projection

The estimation results are presented in Figures 6 through 9. Figure 6 reports impulse response functions to a monetary policy shock estimated in a Local Projection that encompasses two different identification, "RR" and "RR-CS" over the sample Jan. 1991 through Dec. 2008. The solid blue line in each panel depicts the impulse response of the specified variable (Federal funds rate-ffr, real industrial production-ipd, the unemployment rate-uer, headline CPI-cpi, real durable consumption-cdr, real non-durable consumption-cnd, real house prices-hpi, and average corporate credit spreads-csp) to a one standard deviation monetary policy shock, "RR", identified in the equation (1). On the other hand, the red dotted line in each panel depicts the impulse response of the specified variable to a one standard deviation identified in the equation with Baa corporate credit spreads, using the "RR-CS" shocks as the policy variable. Shaded bands and red dashed lines denote the associated 90% confidence intervals. While the responses are somewhat erratic in both cases, the two alternative models produce notably different responses to the policy shock. In case of RR shock (blue solid line), the near-term effect of a contractionary monetary policy shock causes the federal funds rate to increase about 0.25 percent. Then the rate slowly falls, returning to zero after approximately two years. The shock elicit expansionary effect on output, consumptions, and unemployment, hence deliver real activity puzzles, which are not in line with standard theory of monetary policy[22]. Industrial production begins to rise in the next period and peaks 21 months later. Unemployment falls and reached the bottom around 24 months later. Both industrial production and unemployment rate return to normal after 32 months. The response of house prices and credit spreads are not consistent with the standard monetary theory, as well. Prices display

[21] The hybrid-VAR specifications have been used also in Coibion (2012), Barakchian and Crowe (2013), and Ramey (2016).

[22] These results echo those of Barakchian and Crowe (2013), who show that the leading specifications imply expansionary effects in the sample from 1988 through 2007; contractionary monetary policy shocks appear to be expansionary.

some unusual oscillations, though. Prices are affected over the first year in the contractionary way, although they rise over a longer horizon on ward. Overall, the results from using baseline RR shock as an instrument for monetary policy in Figure 6 echo Ramey (2016), who finds no evidence of contractionary effects of monetary policy during the Great Moderation period. Hence, the use of the RR instrument triggers real activity puzzles and price puzzle over a longer horizon. One possible explanation for odd features of the impulse responses shown in Figure 6 is that miss-identification of the policy shock is distorting the estimated impulse responses. Indeed, the results imply that the size and direction of effects of policy shocks to real economic variables depend on the presence of systematic response of monetary policy to credit spreads. In case of RR-CS shock (red dotted line), the impact (near-term) responses of the funds rate, output, the unemployment rate, consumptions, and prices are nearly identical to those in the case of RR shock. By contrast, the two identifications display different dynamics. The federal funds rate rises quickly after the shock and turns negative after about one year and half, which implies that monetary policy becomes more accommodative relative to its initial level. This change in monetary policy stance can be explained by inspecting the real and financial consequences of the shock. In particular, the second model do not give rise to output puzzle although the result does not provide the strong evidence that the shock has significant effect on the economy. As a result from the Figure 6, the use of RR-CS instrument is important to understand the transmission of monetary policy, but it is not sufficient to provide the strong evidence that a contractionary monetary policy shock induces a contraction in output/consumptions, a rise in unemployment/credit spreads, and a reduction in (house) prices.

Next, I consider the effects of the policy shocks identified by equation (3) in section 3. Figure 7 reports impulse response functions to a monetary policy shock estimated in a Local Projection that encompasses the two alternative identification strategies, “RR” and “RR-HP” over the sample form Jan. 1991 through Dec. 2008. The solid blue line in each panel represents the same figures as those in Figure 6. However, the red dotted line in each panel of Figure 7 depicts the impulse response of the specified variable of interest to the identified monetary shocks with house prices, using the “RR-HP” shocks as the policy variable. Interestingly, the RR-HP shocks (red dotted line) in Figure 7 produce similar impulse response functions with those in the case of RR-CS shocks in Figure 6, which can imply that the size and direction of policy shocks to real economy depends on the presence of systematic response of monetary policy to house prices. The Federal funds rate jumps up temporarily but within a few months, then falls back to 0 by a year, which can indicate that the monetary policy become even more accommodative relative to the result from Figure 6. Although the effects of the shocks on real activity are improved, in the way consistent with standard contractionary monetary policy, still there is no significant qualitative differences in precision as in the results of Figure 6. Hence, what the RR-HP and RR-CS shocks have in common is that both cases show IRFs being more consistent with standard macroeconomic theory than those of RR shocks, but each of them does not provide strong evidence to characterize the standard transmission of monetary policy.

By embracing all the implications of the results of Figures 6 and 7, I compare the impulse responses with those in Figure 8, where identification of monetary policy shock is conducted by controlling for the systematic responses to both credit spreads and house prices, simultaneously. The solid blue lines show the baseline results, and the red dotted line in each panel of Figure 8 depicts the impulse response to the identified monetary shocks with credit spreads and house prices, using the "RR-CS-HP" shocks as the policy variable. In contrast with the responses of each variable of interest in Figure 6 and Figure 7, the real activity puzzles become less pronounced and long-lasting quite crucially although response of aggregate prices still remain uncertain. Output and consumptions fall within a month or two and it is significantly persistent over the sample period, while unemployment rate rises, which are consistent with the theory of contractionary monetary policy. Two years after the shock, output has fallen about 1 percent and the unemployment rate has increased about 0.5 percent. Interestingly, the house price drops on impact and significantly contracts over the horizon of the IRF, as documented in Iacoviello (2005), Del Negro and Otrok (2008). In addition, monetary policy causes a sudden tightening in financial conditions, with Baa credit spreads increase on impact significantly as discussed in Gertler and Karadi (2015), Caldara and Herbst (2019). In line with the results showed in Figure 8, Figure 9 provides important evidence that the attenuation occurs in the magnitude of monetary policy shocks to economic fluctuations when the shocks are not identified using both credit spreads and house prices. The blue solid line in each panel shows the response function of economic variables to monetary policy shocks identified using credit spreads only, and the red dotted line provides the estimation results to the identified shocks with both credit spreads and house prices, using the "RR-CS-HP" shocks as the policy variable. The results provide an important evidence that monetary policy shocks induce a significant decline in industrial production that is 30 percent larger than in the previous specifications. The attenuation happens because a drop in corporate spreads and house prices generates a persistent increase in real activity.

The results presented in this section can be stylized in two aspects. The key implication of the analysis presented in this section is that models that without embedding the systematic response of monetary policy to corporate credits spread or house prices identify a monetary policy shock that is contaminated by the endogenous response of monetary policy to the spreads and prices. As shown from the Figures 6 through 8, this section provide the quantitative evidences that shocks constructed without controlling for the systematic response of monetary policy to credit spreads and house prices have no discernible effect on real activity for the Great Moderation period by using the direct estimation method, Local Projection given external instruments. In addition, though the use of identified instrument accounting for the credit spreads or house prices only does not provide strong evidence, but the shocks identified by controlling both credit spreads and house prices simultaneously shows IRFs being more consistent with standard macroeconomic theory as well as it gives strong evidence that a contractionary monetary policy shock induces a contraction in output/consumptions, a rise in unemployment/credit spreads, and a reduction in (house) prices. The reasonable explanation to these finding is that both credit spreads and house prices are either conduit of changes in monetary policy to the real economy and important to quantifying the systematic response of monetary policy to economic and both financial and housing market, which are highly correlated to each other. Consequently, missing this interaction are likely to underestimate the effect of policy for business cycle analysis.

- Results from Hybrid VAR

In the previous part, I established the strong evidence of the presence of a interdependence between monetary policy and two systematic components, credits spreads and house prices. In this subsection, I assess this result to re-examine the VAR structure.

6 Conclusion

What are the effects of monetary policy? Despite being one of the central questions in macroeconomics, and the numerous theoretical and methodological advances, the discussion on the monetary non-neutrality appears to be still controversial by a substantial degree of uncertainty. Indeed, not only the magnitude and the significance, but also the sign of the responses of crucial economic variables such as output and prices depends on the chosen identification strategy, the sample period, the information set considered by monetary authority, and the details of the specification for the estimation model.

This paper helps rationalising unstable and puzzling results discussed in the existing literature by introducing an identification strategy coherent with the intuitions stemming from models of information friction. Especially, my revaluation of the narrative identification of Romer and Romer (2004) clearly point to the existence of a significant systematic response of monetary policy to financial and housing market conditions beyond the well-understood response to real economic activity and prices. Results show a quantitative evidence that terms related to financial condition and housing market performance are frequently mentioned in the transcripts of FOMC monetary policy meetings for Great Moderation period. These mentions tend to occur most during periods of market turbulence from 2000 to 2008. If the instability concerns are irrelevant to setting the federal funds rate, it seems odd that such topics receive such attention at FOMC meetings. In this sense, I argue that accounting for such systematic responses is crucial to understand some of the real activity puzzles in the literature. Importantly, empirical specification that do not controlling for financial conditions and house prices are likely to retrieve dynamic responses that confound the effects of monetary policy shock with the endogenous response of the central bank to changes in the economy, leading the the well-known price and activity puzzles. Indeed, the impulse response analysis provides several crucial empirical results which show that following a monetary tightening controlled by the credit spreads and house prices real economic activity and overall prices contract, lending and consumption cool down, and house prices depreciates. These effects are both sizeable and persistent, suggesting that monetary policy is an effective tool for economic stabilization and stability of financial/housing market. Overall, central to this result is that anything that effect on monetary policy and also has direct effect on real variables, and don't controlling for them, will create an endogenous component to the policy disturbances.

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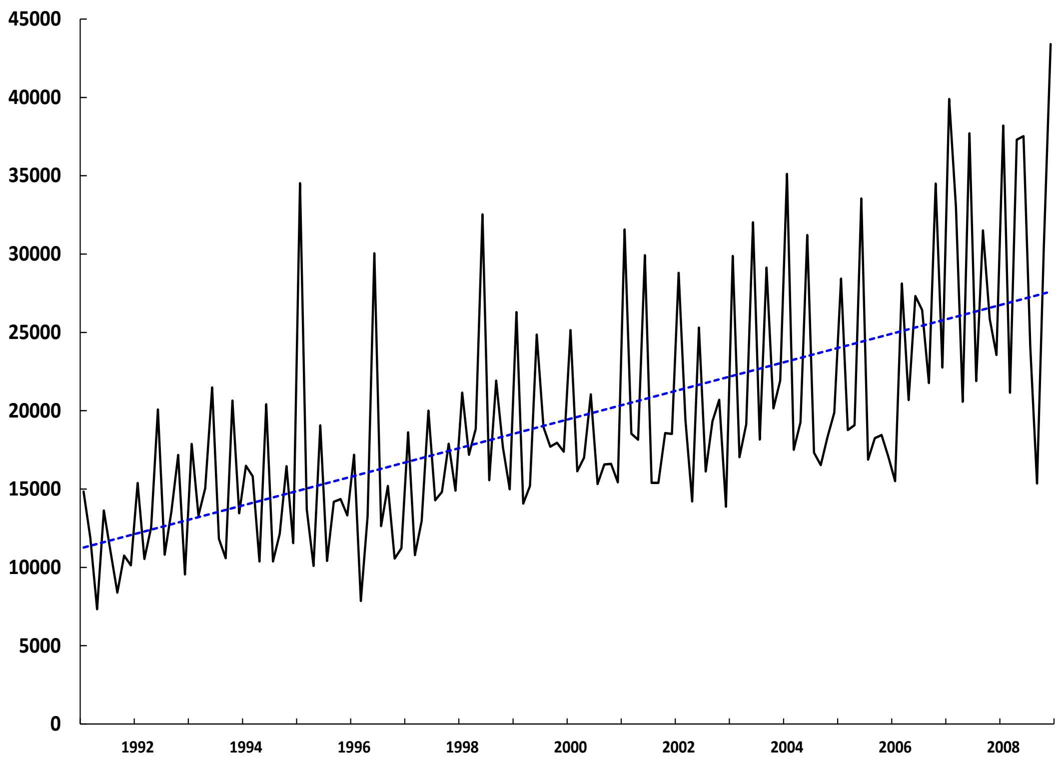
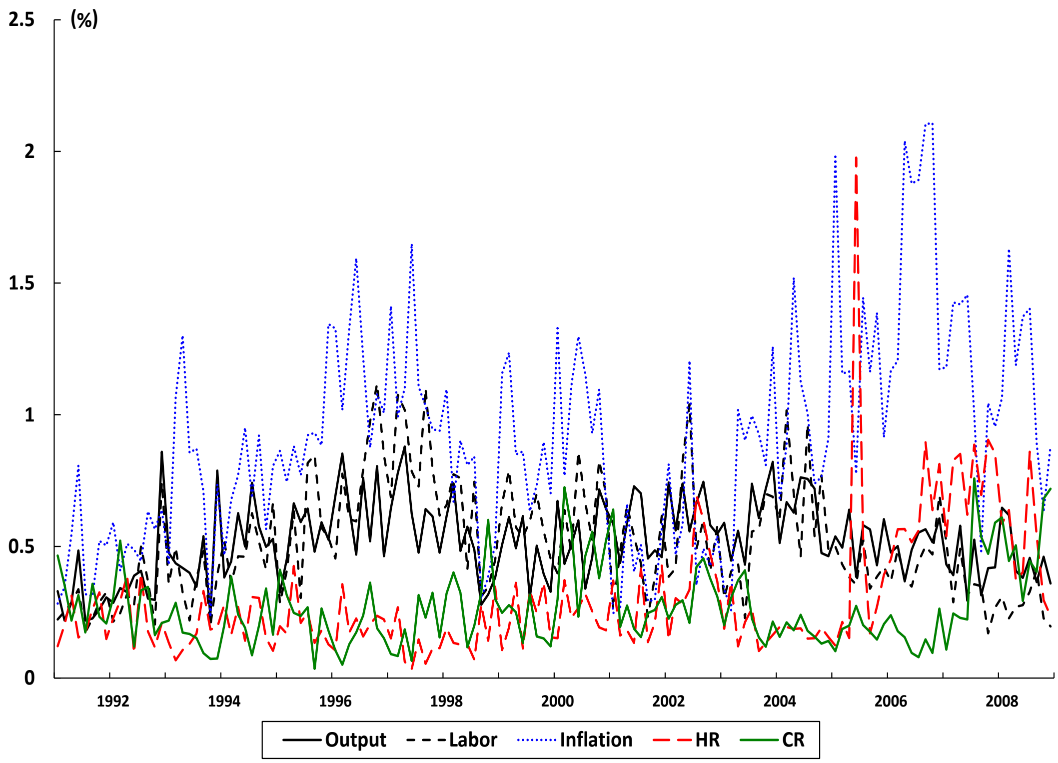
Appendix: Figures

Figure 1: Total Word Count stated by FOMC member at each meeting



Note: The solid black line shows the frequency of words expressed in transcripts at FOMC meeting over the sample period from 1991 through 2008. The dotted blue line represent the fitted line of linear estimation given sample.

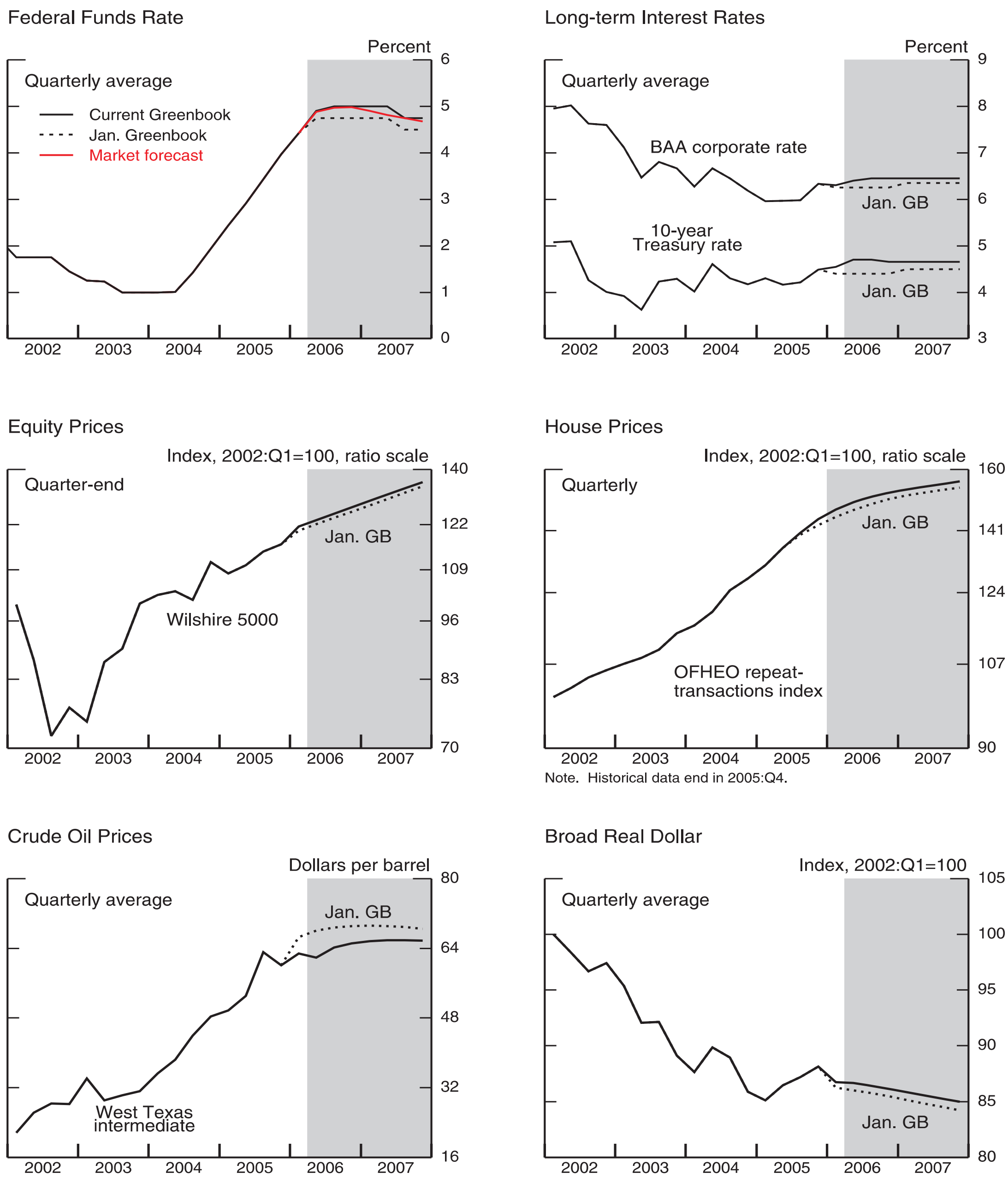
Figure 2: Share of Word Counts for each group, FOMC Transcripts, 1991 - 2008



Note: Each line shows the series of share (%) of word count related to the five economic terms to the total words expressed by members of FOMC at each meeting over the period February 1991 through December 2008; Black-Solid line represents output; Black-Dashed line represents labor; Blue-Dotted line shows Inflation; Red-Dashed line and Green-Solid line illustrate the number of word stated regarding housing prices and credit spread, respectively. The rates of share are plotted on the left axis.

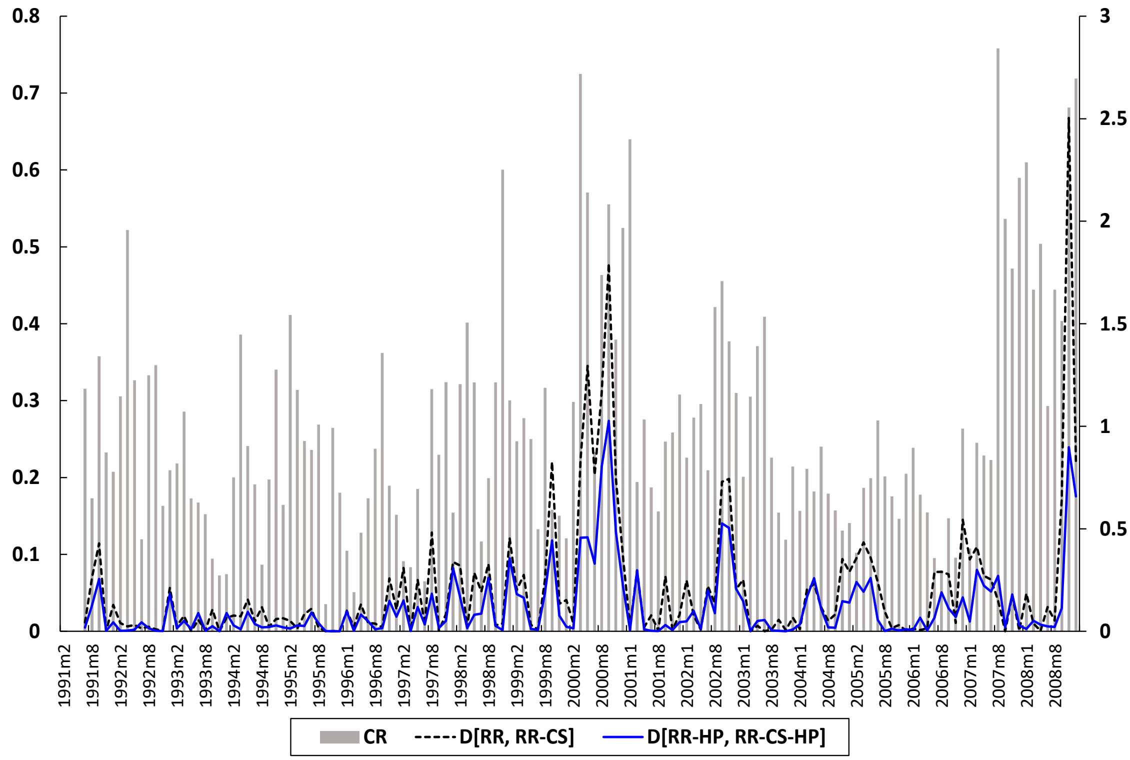
Figure 3: Greenbook forecasts for key background factors, March 2006

Key Background Factors Underlying the Baseline Staff Projection



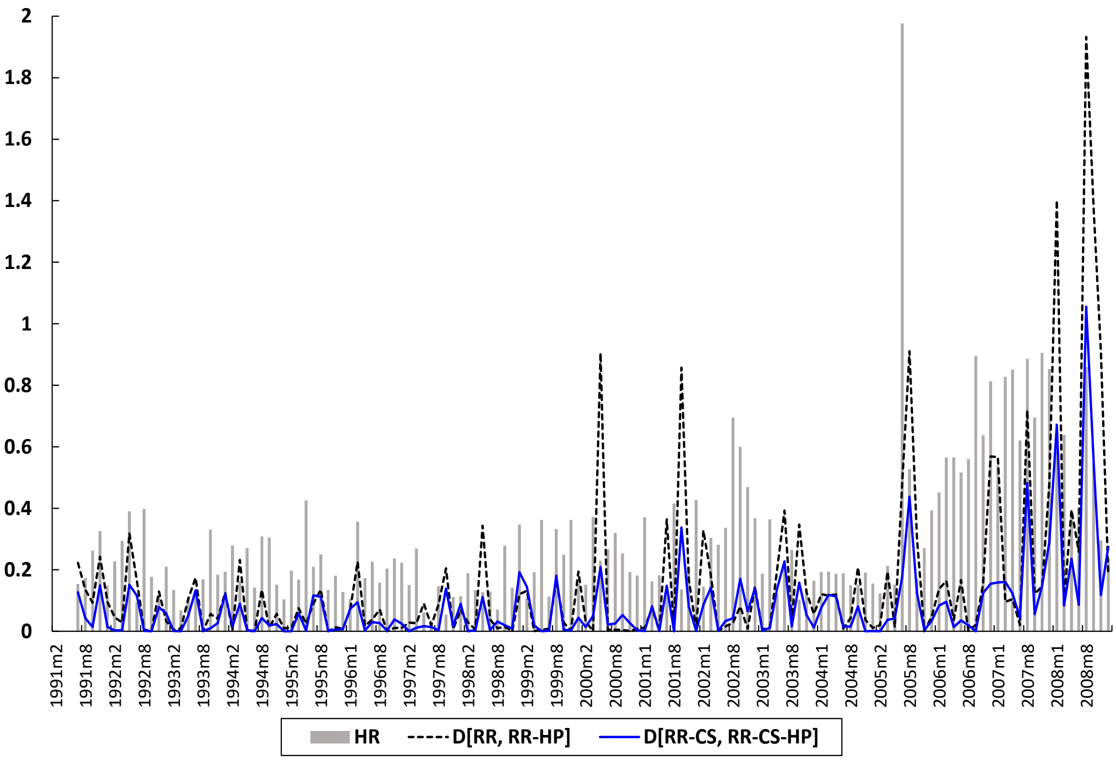
Note. Shading represents the projection period.

Figure 4: Credit Spreads: Texture Analysis and Differences in R&R shocks



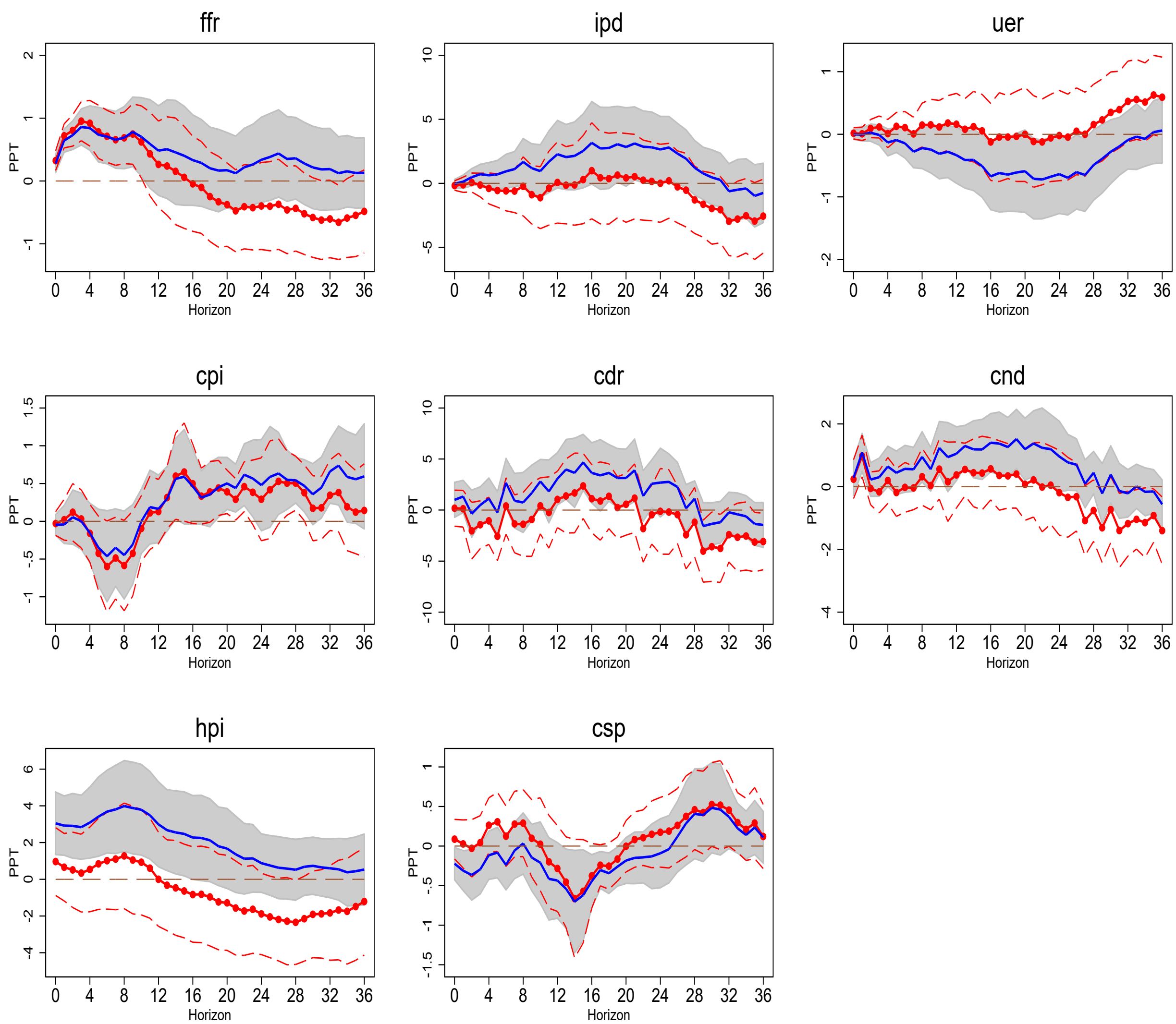
Note: Shaded bars (CR) denote the share (%) of word counts related to credit market performances to the total words expressed for transcripts in each FOMC meeting from July 1991 to December 2008. The rates of share are plotted on the left axis. The re-scaled euclidean distances in residuals are plotted on the right axis; Black-Dashed line for "RR" and "RR-CS", Blue-Solid line for "RR-HP" and "RR-CS-HP"

Figure 5: House Prices: Texture Analysis and Differences in R&R shocks



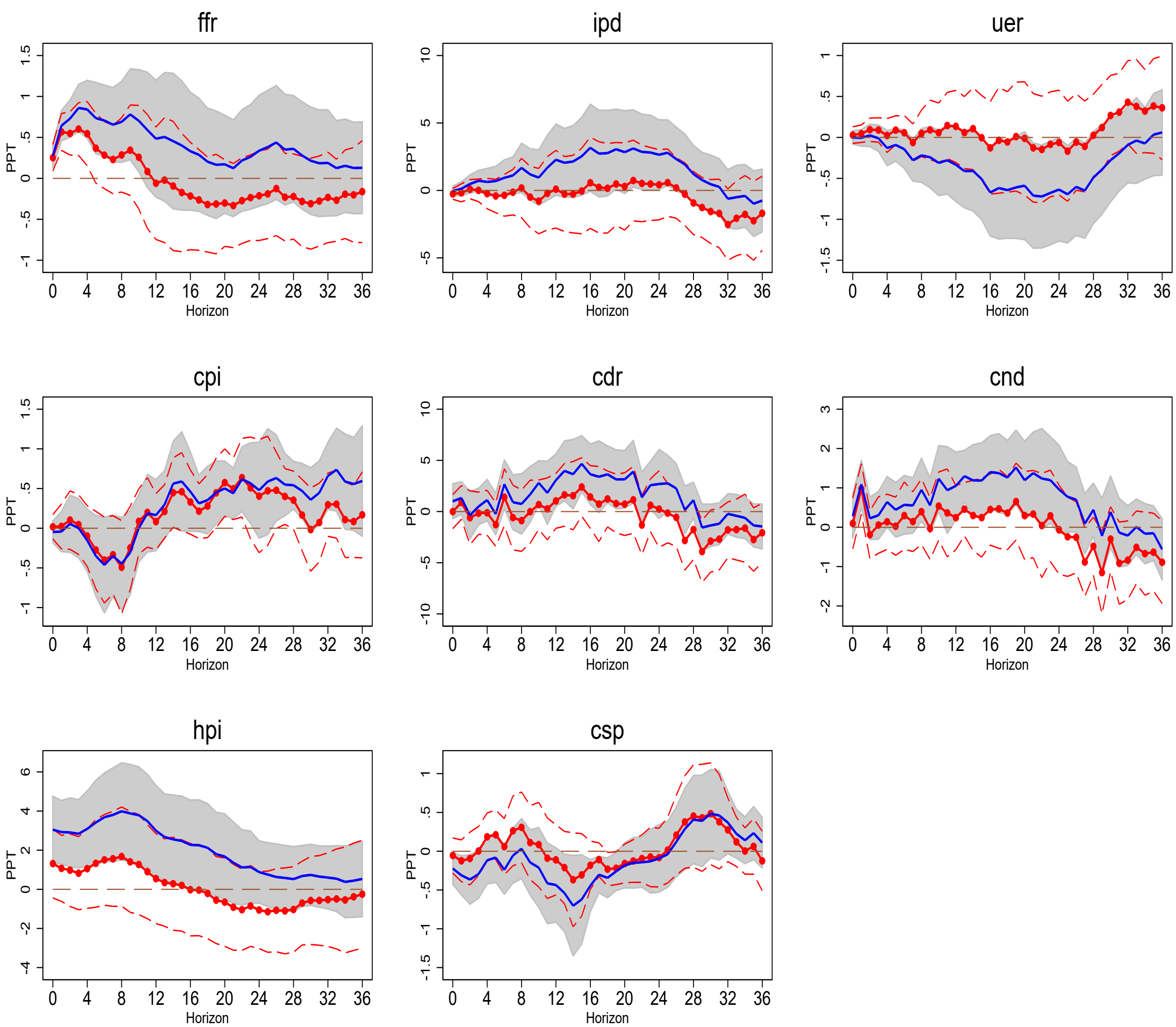
Note: Shaded bars (HR) denote the share (%) of word counts related to housing market to the total words expressed for transcripts in each FOMC meeting from July 1991 to December 2008. The re-scaled euclidean distances in residuals are plotted; Black-Dashed line for "RR" and "RR-HP", Blue-Solid line for "RR-CS" and "RR-CS-HP"

Figure 6: IRs to Monetary Policy Shocks under Different Identification, “RR” and “RR-CS”



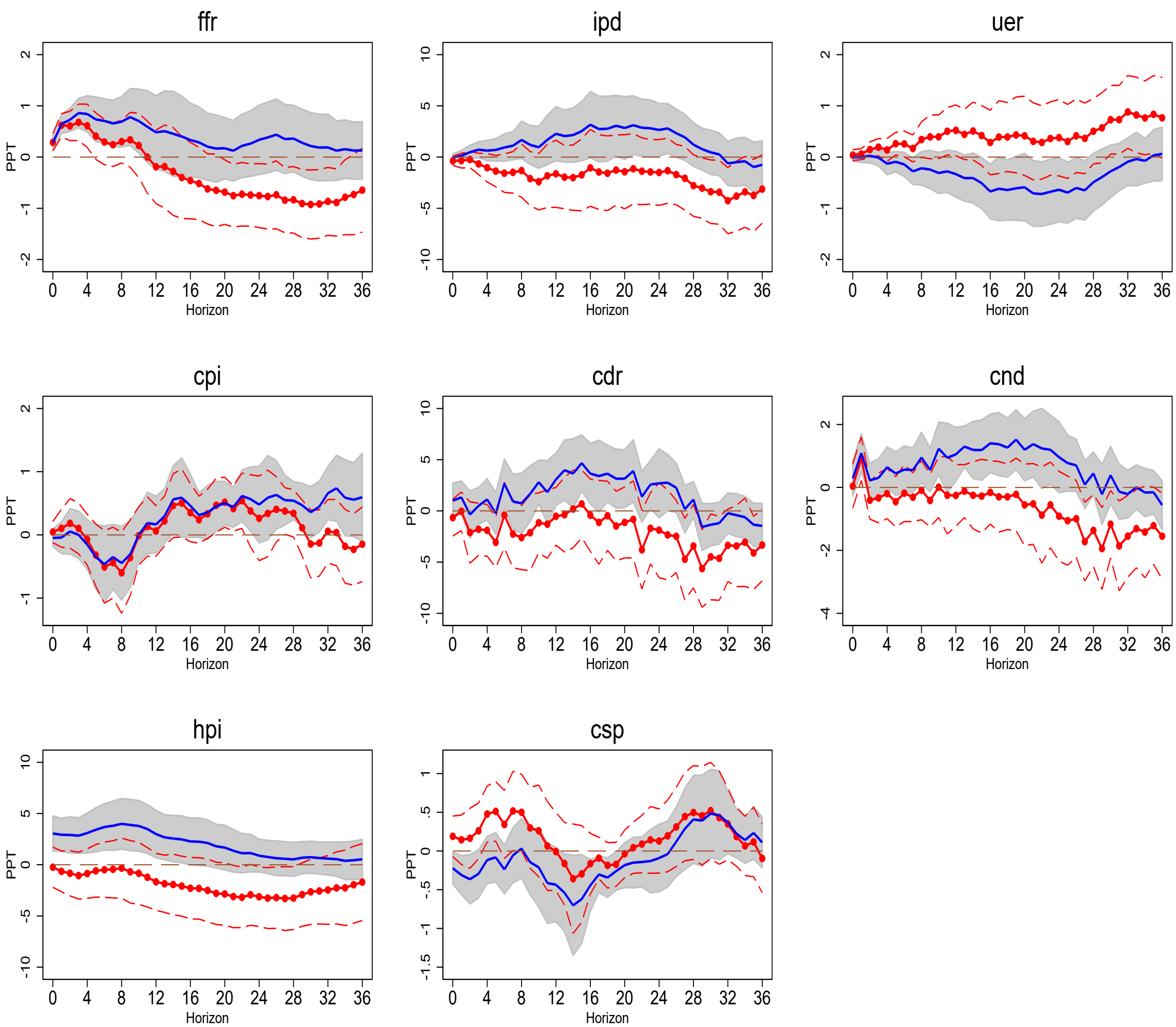
Note: The solid blue line in each panel depicts the impulse response of the specified variable (Federal funds rate, real industrial production, the unemployment rate, headline CPI, real durable consumption, real non-durable consumption, real house prices, and average corporate credit spreads) to a one standard deviation monetary policy shock identified in the R&R (2004) equation. The red dotted line in each panel depicts the impulse response of the specified variable to a one standard deviation identified in the R&R (2004) equation with Baa corporate credit spreads, using the “RR-CS” shocks as the policy variable. Shaded bands and red dashed lines denote the associated 90% confidence intervals. Sample 1991:1 - 2008:12.

Figure 7: IRs to Monetary Policy Shocks under Different Identification, "RR" and "RR-HP"



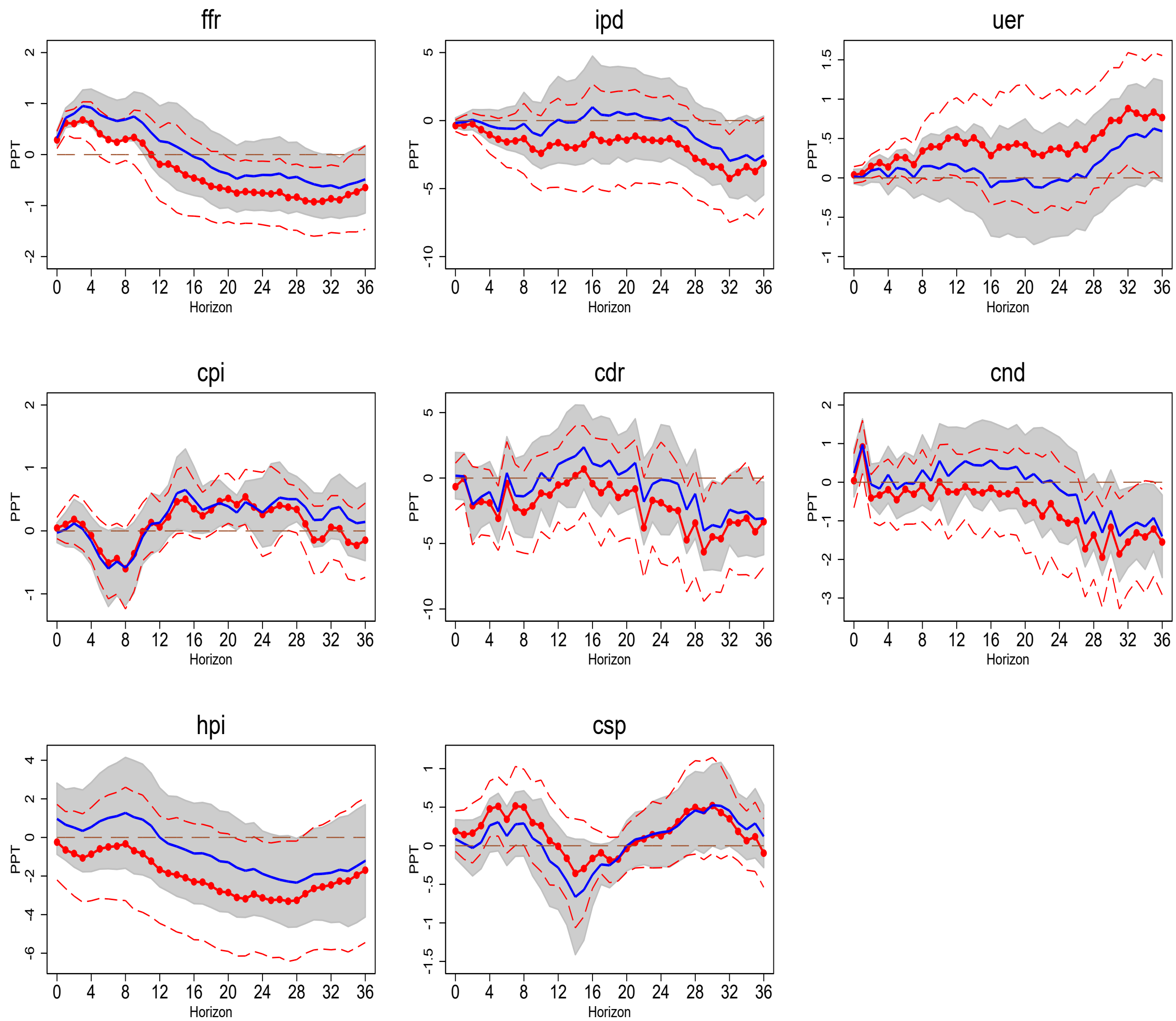
Note: The solid blue line in each panel depicts the impulse response of the specified variable (Federal funds rate, real industrial production, the unemployment rate, headline CPI, real durable consumption, real non-durable consumption, real house prices, and average corporate credit spreads) to a one standard deviation monetary policy shock identified in the R&R (2004) equation. The red dotted line in each panel depicts the impulse response of the specified variable to a one standard deviation identified in the R&R (2004) equation with real house prices, using the "RR-HP" shocks as the policy variable. Shaded bands and red dashed lines denote the associated 90% confidence intervals. Sample 1991:1 - 2008:12.

Figure 8: Dynamic Impulse Responses to Monetary Policy Shocks under Different Identification, “RR” and “RR-CS-HP”



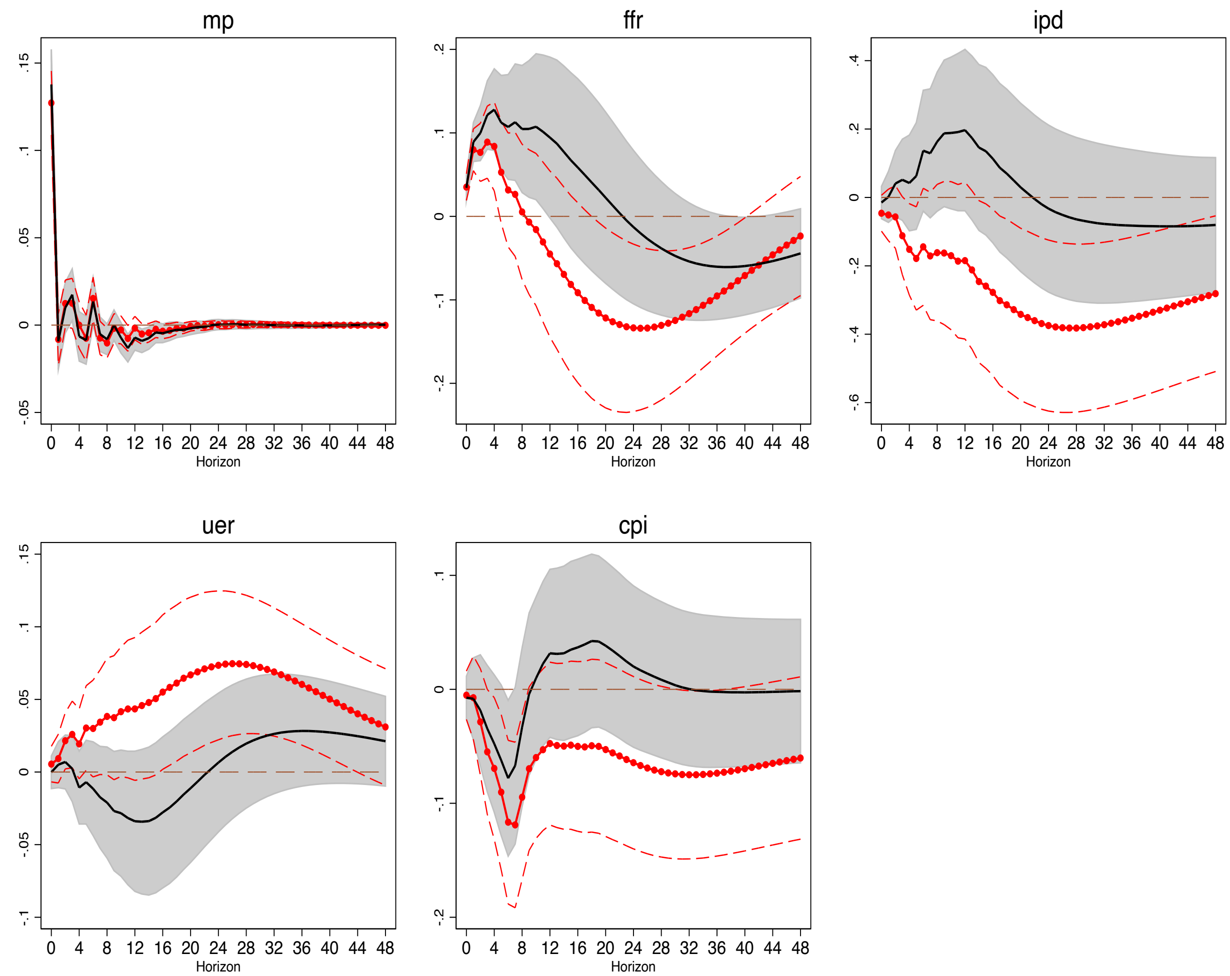
Note: The solid blue line in each panel depicts the impulse response of the specified variable (Federal funds rate, real industrial production, the unemployment rate, headline CPI, real durable consumption, real non-durable consumption, real house prices, and average corporate credit spreads) to a one standard deviation monetary policy shock identified in the R&R (2004) equation. The red dotted line in each panel depicts the impulse response of the specified variable to a one standard deviation identified in the R&R (2004) equation with both Baa corporate spreads and real house prices, using the “RR-CS-HP” shocks as the policy variable. Shaded bands and red dashed lines denote the associated 90% confidence intervals. Sample 1991:1 - 2008:12.

Figure 9: Dynamic Impulse Responses to Monetary Policy Shocks under Different Identification, "RR-CS" and "RR-CS-HP"



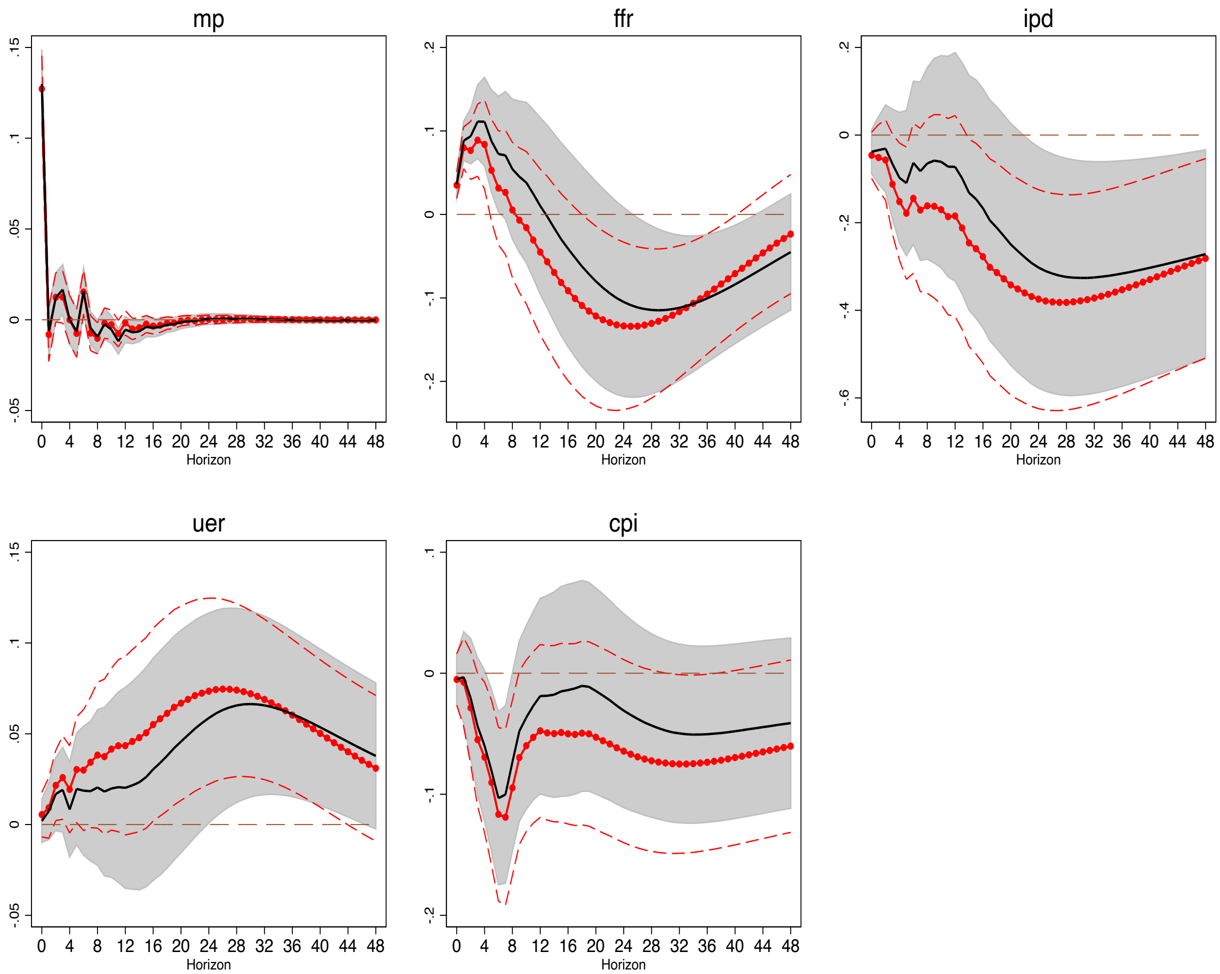
The solid blue line in each panel depicts the impulse response of the specified variable (Federal funds rate, real industrial production, the unemployment rate, headline CPI, real durable consumption, real non-durable consumption, real house prices, and average corporate credit spreads) to a one standard deviation monetary policy shock identified using corporate spreads in the R&R (2004) equation. The red dotted line in each panel depicts the impulse response of the specified variable to a one standard deviation identified in the R&R (2004) equation with both Baa corporate spreads and real house prices, using the "RR-CS-HP" shocks as the policy variable. Shaded bands and red dashed lines denote the associated 90% confidence intervals. Sample 1991:1 - 2008:12.

Figure 10: Alternative Approach (VAR): Dynamic Impulse Responses to Monetary Policy Shocks under Different Identification, “RR” and “RR-CS-HP”



Note: The solid black line in each panel depicts the impulse response of the specified variable (Policy shock, federal funds rate, real industrial production, the unemployment rate, and headline CPI) to 100 basis point deviation of monetary policy shock identified in the R&R (2004) equation. The red dotted line in each panel depicts the impulse response of the specified variable to 100 basis point deviation of monetary policy shock identified in the R&R (2004) equation with both Baa corporate spreads and real house prices, using the “RR-CS-HP” shocks as the policy variable. Shaded bands and red dashed lines denote the associated 90% bootstrap confidence intervals for the system estimated over the sample period, 1991:1 - 2008:12.

Figure 11: Alternative Approach (VAR): Dynamic Impulse Responses to Monetary Policy Shocks under Different Identification, “RR-CS” and “RR-CS-HP”



Note: The solid black line in each panel depicts the impulse response of the specified variable (Policy shock, federal funds rate, real industrial production, the unemployment rate, and headline CPI) to 100 basis point deviation of monetary policy shock identified using corporate spreads in the R&R (2004) equation. The red dotted line in each panel depicts the impulse response of the specified variable to 100 basis point deviation of monetary policy shock identified in the R&R (2004) equation with both Baa corporate spreads and real house prices, using the “RR-CS-HP” shocks as the policy variable. Shaded bands and red dashed lines denote the associated 90% bootstrap confidence intervals for the system estimated over the sample period, 1991:1 - 2008:12.