Does the Federal Reserve respond to house prices? Implications for monetary policy*

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Abstract

This paper revisits Romer and Romer's (2004) narrative identification approach to monetary policy shocks by allowing a monetary authority to respond systematically to corporate credit spreads and real house price dynamics. The paper documents the systematic response of interest rates to these variables and shows that accounting for this systematic response solves an observed empirical puzzle in the literature, where unanticipated increases in the interest rate, instead of contracting the economy, acted as expansionary shocks during the Great Moderation period. Specifically, it investigates the Federal Open Market Committee (FOMC) transcripts using natural language processing tools, to document the increased importance of house prices in discussions among FOMC members about the implementation of monetary policy.

Keywords: Monetary Policy, House Prices, Textual Analysis, Narrative Identification, External Instruments

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1 Introduction

Standard macroeconomic theory suggests that an unexpected increase in interest rates should generate a contraction in real economic activity and reduce inflation, acting as typical demand shocks. This is the basis of the Federal central bank's monetary policy. However, this evidence has been challenged recently (see Ramey, 2016 for a discussion) as in the post-1984 period, known as the Great Moderation, it is difficult to empirically uncover theoretically consistent responses for economic variables to unexpected changes in interest rates.

Figure 1 compares the impulse responses of the Federal funds rate, industrial production, the unemployment rate, and the aggregate price level to traditionally used, narratively identified monetary policy shocks, as in Romer and Romer (2004), for two different sample periods: 1969 to 1990 and 1991 to 2008[1]. The responses of the first sample period (in solid black lines and shaded areas) follow the classic effects of monetary policy shocks, which are consistent with conventional macroeconomic theory. A 100 basis point increase in the Federal funds rate results in a recession: industrial production falls and unemployment increases, but both recover towards their steady-state levels after four years. Prices, as measured by CPI, decline after the initial increase, a phenomenon usually referred to as a price puzzle. The responses for the second subperiod, depicted in blue dotted lines, show instead that increases in the Federal funds rate raise industrial production and lower the unemployment rate. These results echo Barakchian and Crowe (2013) and Ramey (2016), who show that the traditional specifications imply that contractionary monetary policy had surprising expansionary effects in the sample from 1991 through 2008.

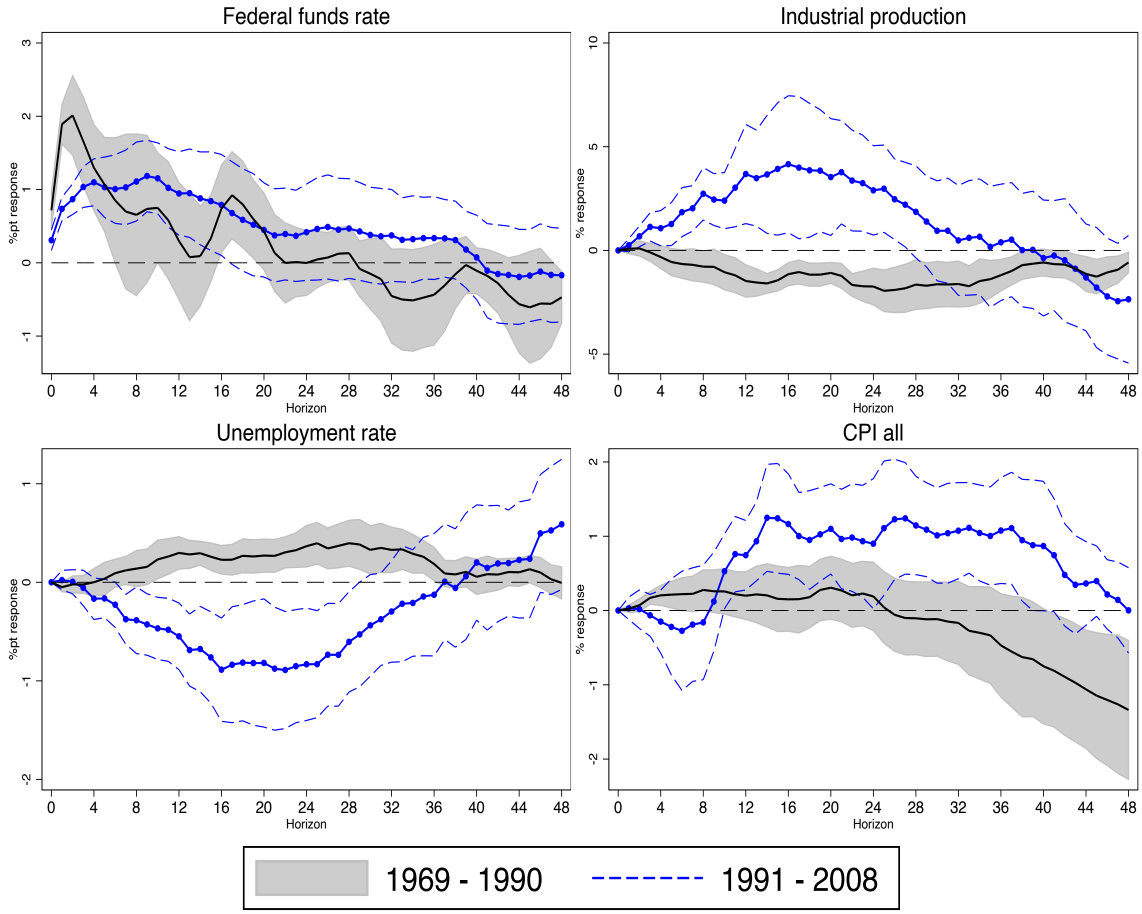
Overall, previous research on the transmission of monetary policy during the Great Moderation period has demonstrated that the estimated dynamic responses to policy innovations are sensitive to using different samples, estimation methodologies, and identification strategies. This paper contributes to the literature on the narrative identification of monetary policy by improving how we account for the systematic response of monetary policy, and shows that controlling for real house prices, in addition to credit spreads, recovers the responses of macroeconomic variables in ways that are consistent with the theory.

This paper contributes to two strands of the literature. First is the literature on the identification of monetary policy shocks.[2] My work is more closely related to Gertler and Karadi (2015) and Caldara and Herbst (2019), which both pay close attention to the shocks' financial conditions, particularly credit cost, as a critical component in the monetary authority's information set when setting the interest rate. There is also a relatively new and fairly scant literature that discusses the relevance of housing prices for monetary policy. Finocchiaro and von Heideken (2013) estimate the

[1] The sample stops in 2008 to exclude the effectively zero low-bound period in the US.

[2] 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, Coibion (2012); Finocchiaro and von Heideken (2013); Arias, Caldara, and Ramirez (2015); Gertler and Karadi (2015); Ramey (2016); Aastveit et al. (2017); and Caldara and Herbst (2019).

Figure 1: Jordà local projection with R&R monetary policy shock



Note: The solid black line in each panel depicts the impulse response function of the specified variable (Federal funds rate, real industrial production, the unemployment rate, and headline CPI) to a 100 basis point deviation of the Romer and Romer (2004) monetary policy shock for 1969-1990, based on Jordà's local projection method (Jordà, 2005). The blue dotted line in each panel shows the response function of the specified variable to a 100 basis point deviation from the Romer and Romer (2004) monetary policy shock for 1991-2008. Shaded bands and blue dashed lines denote the associated 90% confidence intervals.

house price coefficient in a monetary policy feedback rule and find evidence of a positive and significant response of interest rates to house prices in the US, specifically in the context of a DSGE model. A similar result emerges in Aastveit et al. (2017), who show that the Federal Reserve had responded systematically to house prices but this response changed over time, using a VAR model with time-varying parameters and stochastic volatility. My paper instead evaluates the role of house prices for the identification of monetary policy shocks, by revisiting Romer and Romer's (2004) narrative identification strategy.

My first contribution to this literature is providing evidence of the relevance of house prices for monetary policy decisions, by applying standard natural language processing (NLP) analysis.

To show that house prices are on the radar of policy makers is a necessary, though not sufficient, condition for arguing for the relevance of house prices in decision-making. I use a direct measure of mentions of housing-related words that appear in Federal Open Market Committee (FOMC) discussions from 1991 M2 to 2008 M12. In this step, I define five groups of terms related to major macroeconomic variables that are relevant for monetary policy: “Inflation,” “Output,” “Labor,” “Housing,” and “Credit.” I then derive the frequency of words expressed in each group compared to all five groups. This set-up allows me to track the systematic reactions of monetary policy to the five components in each FOMC meeting over my sample period.

I find that housing- and credit-related terms account for 11.23 percent and 15.62 percent, respectively, of the total words identified to be important for monetary policy over the whole sample period. Interestingly, a word search suggests that terms associated with the housing market appeared frequently after 2000. Before 2000, the average frequency of words related to housing was only 8.85 percent, but it increased by 5 percentage points after 2000. By contrast, the frequency of labor-related terms decreased after 2000. Though this finding does not necessarily identify why house prices are important for the policymakers, i.e., it might because they have been moving a lot or because the policymakers prefer to stabilize them, it still provides suggestive evidence for the importance of house prices in FOMC discussions, above and beyond the regular variables traditionally considered to be important for monetary policy.

Does accounting for house price movements improve the identification of monetary policy shocks? To characterize this question, I revisit the narrative approach to monetary policy shocks discussed in Romer and Romer (2004) by re-constructing their monetary policy shocks (the baseline specification throughout this paper) with two changes to their identification framework. I expand the earlier model by adding indicators of both real house prices and credit spreads into their identification regression equation. The estimated residuals in the expanded model constitute the newly proposed narrative measures of the policy innovations matching the FOMC (regular) meeting frequency. These newly orthogonalized monetary policy shocks resolve various puzzle-type effects in output, inflation, and other variables previously discussed in local projections or structural VAR frameworks, at last reconciling the effects of the monetary policy with traditional macroeconomic theory.

Notably, the estimated results show that the central bank reacts to changes in the Baa spread beyond the information contained in the Greenbook forecasts. Consistent with the evidence from Caldara and Herbst (2019), FOMC meetings occurring in periods with elevated levels of corporate credit spreads are associated with cuts in the intended Federal funds rate. While the results on the responses to credit spreads are in line with the previous literature, one new finding is that the response to real house price growth is also important. The empirical evidence, though in a different empirical context, shows that the central bank systematically and positively responded to real house price growth for the 1991-2008 period, consistent with Aastveit et al. (2017).

More importantly, accounting for the systematic reactions of policy to house prices has a significant role in understanding the transmission of monetary policy shocks in terms of standard macroeconomic theory, i.e. interest rate surprises generate recessions, which are accompanied by declines in prices. I further show that the results are robust to various estimation strategies by considering both local projections as well as hybrid-VAR-based responses. For all the different estimation methods, the empirical findings support the importance of incorporating house prices to understand the transmission of monetary policy shocks to the macroeconomy during the Great Moderation period.

The rest of the paper is structured as follows. Section 2 describes the NLP procedure utilized in the paper and the results on the frequency of topics mentioned in FOMC transcripts. Section 3 revisits the narrative identification of monetary policy shocks proposed by Romer and Romer (2004) and derives a new measure of the policy shocks, by adding two important systematic components into their estimation framework. Sections 4 and 5 examine narrative-based identification of the effects of monetary policy on macroeconomic variables in local projections and structural VAR frameworks. Section 6 discusses the implications of my results for monetary policy and lays out some ideas that hold promise for future research.

2 Discussion of FOMC Transcripts

Have house prices been important for discussions about establishing monetary policy? To engage this question, this section proposes a measure of the central bank's preferences associated with identifying exogenous policy shocks and with determining whether or how policy makers consider those shocks. I accomplish this by examining the FOMC's preferences directly by evaluating participants in the FOMC monetary policy meetings. In particular, I measure the presence of the Fed's systematic responses to house prices by applying standard natural language processing (or textual analysis) to publicly available FOMC meeting transcripts. That is, rather than basing the measure on specific events or numerical data and having to investigate whether the FOMC is sufficiently concerned about them, I use a direct measure of mentions that actually appear in FOMC discussions.

Since these word counts are taken directly from FOMC meeting transcripts, they are particularly well suited for explaining the behavior of the FOMC. In general, examining such an indicator should highlight the degree of importance the FOMC accords to maximum employment, prices, and financial stability, and hence their importance to the implementation of monetary policy. For instance, if FOMC members never discuss housing markets at these meetings, it would be difficult to argue that the stance of monetary policy has been affected by concerns about housing market performance. If the committee does discuss financial instability concerns, then it either cares about financial instability separately or believes that the forecast has not incorporated these concerns fully or accurately enough. My key finding from the the textual analysis is that the FOMC significantly considered housing (and credit) markets, 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 textual data source is the public archive of FOMC transcripts, which are the most detailed records of FOMC meeting proceedings, and can be obtained directly from the Federal Reserve Board of Governors website with a five-year lag. Specifically, the FOMC Secretariat produced the transcripts shortly after each meeting from an audio recording of the proceedings, lightly editing the speakers'original words to facilitate readers'understanding. Meeting participants are given an opportunity in the subsequent several weeks to review the transcript for accuracy[3]. These transcripts cover all regular FOMC meetings from 1976 to 2015, though I only make use of February 1991-December 2008 transcripts in this paper given other data constraints. To this end, my baseline sample is scheduled FOMC meeting days from February 1991 to December 2008, when the Federal funds rate hit the zero lower bound.

I do not use days with unscheduled FOMC meetings. The main reason for this is pragmatic: the test in the following section for the presence of a systematic response of monetary policy to financial conditions and house prices uses the projections from the Greenbooks for the Federal Reserve Board of Governors. Greenbooks are produced only before each scheduled FOMC meeting, so they are not available for unscheduled meetings.[4]. Since the FOMC had eight scheduled meetings per year, my samples include a total of 144 transcripts.

The textual analysis provides narrative evidence for estimating the Fed's preferences, relying on the assumption that the central bank's concerns are embedded in the words spoken by the policy makers at internal meetings. Accordingly, I count the frequency of terms expressed by FOMC members, which can be related to the systematic components of monetary policy, including implicit inflation targets, economic growth, and financial and housing market performance. The advantage of this approach is that it could be used internally and externally to study the preferences of any central bank with transcripts, statements, or detailed summaries of their policy-making deliberations.

Initially, I convert all the transcripts from PDF format to text files, then apply several filters to

[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 also been lightly edited by the Secretariat, some errors undoubtedly remain since the raw transcripts were not fully edited for accuracy at the time they were prepared. At that time, they were intended only as an aid to the Secretariat in preparing meeting minutes. While some have questioned whether it is appropriate to use the transcripts before 1994, to my knowledge this is the best data available to the public and is 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, as 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. My sample has 52 unscheduled meetings out of 196 total events from February 1991 to December 2008.

remove words likely to be especially noisy. I proceed in three steps. Once a corpus, a collection of text documents, is created, I modify the documents to aid later analysis. First, I drop punctuation, except for inter-word dashes. Second, I remove extra white space and "stop-words," defined as common words that usually have no analytic meaning in English. Third, I reduce word forms to stems, which makes any form of a term 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; hence I combine them (or reduce them) to a meaningful acronym.

I begin my analysis by defining five different groups in a list of terms related to a specific economic variable. Table 1 provides a list of the words I select for each group. The group "Inflation" is composed of terms that might be related to price stability, such as inflation expectation, deflation, and several price indexes. The words for the group "Output" are related to economic growth, such as output gap, potential output, GDP, industrial production, slack, utilization, recession, and economic activity. The list of words in the group "Labor" are unemployment, labor, hire, jobless, and natural rate, all of which are associated with unemployment rates. In the group "Housing", I choose several terms that might be highly related to housing markets, such as housing sector, house (home, housing) price, home-ownership, residential, mortgage, Fannie Mae, Freddie Mac, OFHEO (Office of Federal Housing Enterprise Oversight), foreclosure, and collateral. Lastly, the group "Credit" is composed of words that could be highly associated with credit market performances, e.g., credit spreads, treasuries, corporate bonds, yield curve, and forward rate. To classify the key economic terms, I follow Peek et al. (2016) and Shapiro and Wilson (2019, 2021), specifically using their filtered subsets of transcript text for "Inflation," "Output," and "Labor." For the lists of transcript text for housing and credit, I use my own specification[5] after selecting and investigating several representative meeting transcripts.

Given a collection of text documents and categorization, I calculate the total number of words stated for each group of transcript text. An important issue is that, as seen in Figure 2, the total word count for transcripts in each FOMC meeting increased over the sample period, from under 11,000 words in 1991 to about 31,000 words in 2008. Accounting for that, I compute the frequency of words expressed in each group vs. in all five groups[6] I defined. The associated results are shown in Table 2, which provides the average frequency of terms expressed for each group and the total number of times these words are mentioned in the FOMC meeting transcripts, across the three different sample periods. During the full sample period from 1991 to 2008, the average total number of words mentioned in each FOMC meeting was 19,431; on the other hand, the frequency of terms selected in all five groups accounts for 2.63% on average of the total number of words expressed. Within the five groups, in particular, the terms related to Output, Labor, Inflation, Housing, and

[5]The main point is to understand how the FOMC members described which topic and who described them at each meeting. Based on this, word classification was carried out for the last two groups. In that sense, subjectivity inevitably played a role in the selection of which words to examine. The purpose of the selection, however, is to identify terms that are likely to be used to address concerns about the housing and credit markets.

[6]For instance, the frequency of terms associated with the group "Inflation" in a given FOMC meeting can be computed as, $\frac{\text{\# of words expressed in the group Inflation}}{\text{\# of words expressed in all five groups}} \times 100$

Table 1: List of Economic Terms in Each Group

Inflation	**Output**	**Labor**	**Housing**	**Credit**
			house	
inflation	output		home	
inflation expectation	output gap		house price	
inflationary	potential output	unemploy	home price	credit
inflationary expectation	gdp	unemployment	housing price	credit spreads
deflation	industrial production	nonemploy	housing related	treasuries
deflationary	slack	employ	housing sector	bond
disinflation	utilization	employment	homeownership	corporate bond
disinflationary	recession	natural rate	residential	yield curves
consumer prices	expansion	labor	mortgage	securities
producer prices	economic activity	hire	fannie mae	forward rate
cpi	economic growth	jobless	freddie mac	
pce	economic development		ofheo	
price stability	economic performance		foreclosure	
			collateral	
13	13	9	15	8

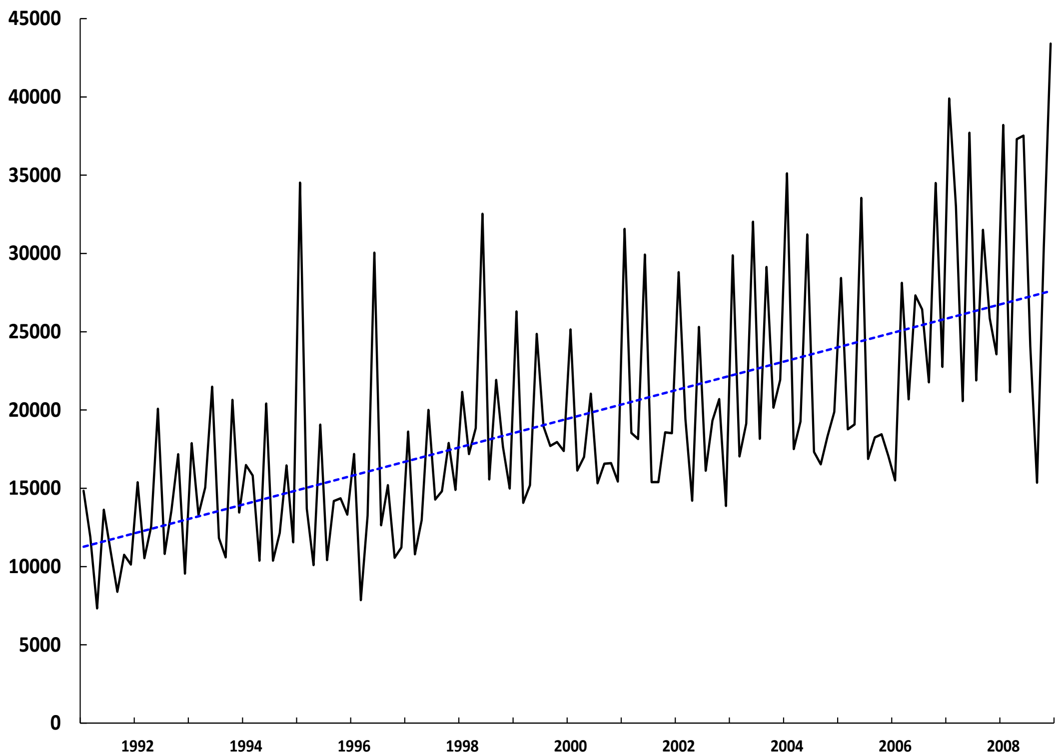
* For inflation, output, and labor, see Peek et al. (2016) and Shapiro and Wilson (2021). Otherwise, my own specification.

Credits account for 20.18%, 19.45%, 33.52%, 11.23%, and 15.62% on average, respectively.

The results of this word search imply three key elements of FOMC preferences. First, the results indicate that the frequency of terms associated with the groups "Inflation" and "Output" have on averaged about 33% and 20%, respectively, over the entire sample period. There is no noticeable change in those frequencies across the Pre- and Post-period. These findings are consistent with the fact that the Fed conducts monetary policy to promote stable growth in economic activities and prices (see Walsh, 2017), which is commonly known as the dual mandate. Second, the results show that the frequency of terms related to "Credits" averages 15.5% over the full sample period, which can imply that the Fed was steadily concerned with credit market performances during the Great Moderation period, which is compatible with findings by Caldara and Herbst (2019). Finally, the results support the fact that the Fed considered the housing market when they discussed the monetary policy and whether its extent had changed. For the Pre-period from 1991 to 1999, the average frequency of terms related to the group "Housing" was 9%, which is about half the frequency of those from the "Output" or "Labor" groups. However, the average "Housing" frequency increased to 14% during the Post-period, a comparatively large proportion compared to the other groups. Overall, a preliminary reading of the transcripts[7] clearly indicates that housing market concerns were discussed by FOMC members, with the key terms appearing more frequently during the

[7]For comparison purposes, I compare the frequency of terms for each group I defined to the total number of words expressed at each FOMC meeting in my sample period. In this case, from 1991 to 2008 the overall average frequency was 0.5% for output and labor, 1% for inflation, and 0.3% for housing and credits. The frequency levels using the total number of words in each FOMC meeting are much less than those using the number of words in all five groups, but the trends across periods are similar. The associated results are described in Table A.1 and Figure A.3 in the Appendix.

Figure 2: Total word count stated by the FOMC members at each meeting



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

Post-period.

Figure 3 provides a graphical description of how the frequency of the words in each group at each FOMC meeting moves for the period 1991 to 2008. The solid black line in Figure 3 represents the group "Output." The black dashed line indicates the group "Labor." The black dotted line shows the group "Inflation." The blue and red solid lines describe the frequency of terms related to housing and credit, respectively. The results from Table 2 and Figure 3 indicate two points. First, inflation-related words were consistently mentioned at each meeting, at an average rate of 33% over the entire sample period. On the other hand, terms related to output, labor, housing, and credit showed different frequencies and varied across the sample period. Specifically, the frequency of words related to output and labor maintained an average of about 20% until the early 2000s. Then the number sharply decreased, showing a frequency of about 10% in 2008. In contrast, the frequency of words related to housing and credit changed significantly in the late 1990s. Before

Table 2: Frequency of terms expressed by the group across the sample

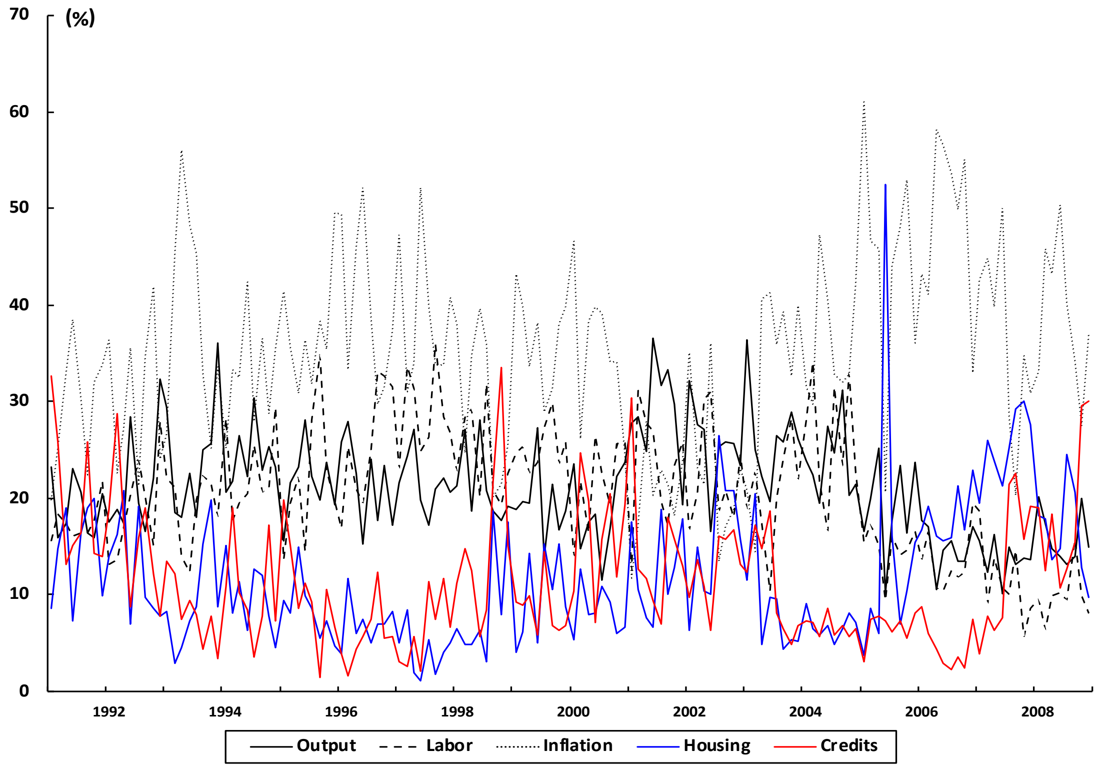
Group (%)	Full sample: 91-08	Pre-period: 91-99	Post-period: 00-08
Output	20.18	20.51	19.85
	[5.226]	[4.397]	[5.954]
Labor	19.45	21.48	17.43
	[6.612]	[5.711]	[6.866]
Inflation	33.52	33.09	33.95
	[10.036]	[8.054]	[11.73]
Housing	11.23	8.85	13.61
	[7.001]	[4.676]	[8.083]
Credits	15.62	16.08	15.16
	[8.329]	[8.53]	[8.158]
All groups (#)	521	373	670
Total (#)	19431	15549	23314

1998, the frequency of words related to housing and credit reached around 10% on average, which is less than half of the frequency of other groups during the same period. However, from 1999 the frequency of words related to housing and credit gradually increased, reaching about 15% on average until the early 2000s, which is consistent with the findings from Peek et al. (2015), Walsh (2017), and Shapiro and Wilson (2019), who argue that the FOMC systematically responded to financial variables in this period. Further, the frequencies of both groups rose sharply from 2005 onward. Housing-related frequency exceeded an average of 20%, while credit-related frequency accounted for about 18% on average. Those frequencies were relatively high, considering that the frequencies of terms related to output and labor were both less than 15% in this period. Overall, the housing sector and credit market performances were steadily and non-negligibly discussed by the FOMC members, along with concerns about full employment and price stabilization, which implies that those are the systematic components in the central bank's information set. This result suggests that a simple dual-mandate-style reaction function, which does not consider concerns about the financial market, may not capture the actual behavior of monetary policymakers. In this sense, these findings are consistent with those obtained earlier by Aastveit et al. (2017) and Caldara and Herbst (2019).

There is, in fact, considerable external support for these results. 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 the IT

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

Figure 3: Frequency of word count for each group, FOMC transcripts, 1991 - 2008



Note: Each line represents the frequency (%) for the five groups of words mentioned in the transcripts of each FOMC meeting, from February 1991 to December 2008.

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 both cases, FOMC participants recognized the serious volatility of financial markets at their meetings during these two periods, and discussed potential ways to stabilize them. Below is an excerpt from the transcript of the November 17, 1998 FOMC meeting, where FOMC participants explicitly expressed their concerns for stability in financial markets.

> **Excerpt from a transcript of the 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.

As can be seen in Table 2 and Figure 3, the proportion of housing-related words has increased rapidly since 2005. Starting with the FOMC meeting in June 2005, the frequency of these terms, accounting for more than 50%, has increased significantly. The FOMC participants at the June 2005 meeting used terms related to housing at an unprecedentedly high level, considering that the share of words related to inflation was 61% at the February 2005 meeting, the highest during the entire sample period. From then on, housing-related words were expressed frequently, with an average 20% share from 2005 to 2008. These results imply that the central bank had a considerable concern for the housing markets when developing their rules for establishing monetary policy. Interestingly, the changes in frequency for the housing group were highly related to aggregate house prices. Indeed, by 2005 the growth rate in real house prices had been increasing significantly since the early 2000s and it peaked in November 2005. Notably, participants in the FOMC meeting in June 2005 discussed this issue from various perspectives. Particularly, they tried to find out which models could best capture the macroeconomic implications of changes in house prices. The following is an excerpt from the transcript for June 30, 2005, in which some FOMC participants explicitly stated performance goals for the 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.

Overall, the results in Section 2 indicate two insights. First, by directly measuring the central bank's preferences in the FOMC meeting transcripts (1991-2008) using textual analysis, I can suggest that the Fed explicitly considered the housing market conditions during their decision-making, which can imply the presence of a crucial interdependence between monetary policy and house prices during the Great Moderation period from 1991 to 2008. Second, in contrast with conventional wisdom, identifying the monetary policy shocks without accounting for the endogenous reactions induced by the housing market performances would exhibit the confounding effects of monetary policy on the real economy, especially for the Great Moderation period. Apparently, this narrative 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 a new measure of exogenous monetary policy shocks by making two changes to Romer and Romer's (1989, 2004) estimation framework.

3 Policy surprises

The previous section provides a narrative result using textual analysis to establish the presence of interdependencies between monetary policy and changes in economic conditions, especially housing and credit market performances. In this section, I build on that result to re-examine the narrative identification of monetary policy shocks by Romer and Romer (2004). I first describe their identification strategy, then propose a new measure of monetary policy shocks by adding two components into their traditional framework. Specifically, I add a measure of the average Baa corporate credit spreads and 3-month moving average of monthly growth in the real house price index. According to the stylized facts I discussed in Section 2, both factors are systematically important, which can endogenously affect monetary policy shocks, especially for the Great Moderation period. Ultimately, I develop monetary policy shocks as shifts to the policy rate that are exogenous to changes in economic conditions (and their revisions), house prices, and corporate credit spreads. Hence, by building on Romer and Romer (2004)'s identification, I propose a new measure of monetary policy shocks that take into account the systematic components, as well as house prices and credit spreads, in the function of the central bank's policy making. At the end of this section, I provide several implications of these findings by comparing them to the narrative evidence generated using textual analysis, which I discussed in the previous section.

In general, narrative approaches involve constructing a series of historical documents to identify the reason and/or the quantities associated with a particular change in a variable. Romer and Romer (2004) proposed identifying monetary policy shocks by using the real-time "Tealbook (formerly 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 before the FOMC meets (usually 5 to 10 days prior), they can be considered exogenous with respect to the committee's dialogue.

Following Romer and Romer (2004), Coibion and Gorodnichenko (2011), and others, my baseline specification is constructed by regressing the 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. These forecasts are typically published a week prior to each scheduled FOMC meeting and can be thought of as a proxy for the information set of the FOMC at the time of making a policy decision. For Δff_m, I update the series of intended Federal funds changes to the end of 2008[9]. The following regression is the original form of the equation introduced by Romer and Romer (2004);

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

where m is the monthly date of the scheduled FOMC meeting, Δff_m is the change in target rate around FOMC meeting m, ffb_m is the level of the intended funds rate before any policy decisions associated with meeting m; $\tilde{u}$, $\tilde{y}$, and $\tilde{\pi}$ refer to the Greenbook forecasts of the unemployment rate, the real output growth, and inflation, respectively (prior to the choice of the interest rate); and i is the index in the summations that refers to the horizon of the forecasts. The equation includes both the forecasts for the contemporaneous meeting and the revision in the forecast from the previous meeting, because it is plausible that both the levels and the changes in the forecasts are important factors in Federal Reserve behavior. The estimated residuals $\hat{u}_m$ are interpreted as policy innovations at FOMC meeting frequency.

The second key contribution of this paper is providing a new measure of monetary policy shocks based on the narrative approach, by reconstructing the conventional Romer and Romer monetary policy shocks with two changes to their estimation framework. Thus, I next include in the regression an indicator of house prices and credit spreads. I then estimate the following equation at FOMC

[9] While Greenbook forecasts are available until the end of 2016 (as of the time of this writing), the interest rates approached the zero lower bound from 2009 onward, so a regression including the sample period after 2009 might not appropriately capture the Federal Reserve's intended rates for policy targets.

meeting frequency over my sample period from 1991 to 2008:

$$\Delta ff_m = \alpha + \beta ffb_m + \delta cs_m^{5D} + \psi \Delta h_m^{2M} + \sum_{i=-1}^{2} \Big[\gamma_i \Delta \tilde{y}_{m,i}\Big] + \sum_{i=-1}^{2} \Big[\lambda_i (\Delta \tilde{y}_{m,i} - \Delta \tilde{y}_{m-1,i})\Big] + \sum_{i=-1}^{2} \Big[\phi_i \tilde{\pi}_{m,i}\Big] + \sum_{i=-1}^{2} \Big[\theta_i (\tilde{\pi}_{m,i} - \tilde{\pi}_{m-1,i})\Big] + \rho \tilde{u}_{m,0} + \varepsilon_m \tag{2}$$

Because Greenbook forecasts for credit spreads are only available starting in 1998, my instrument is instead cs_m^{5D}, the average Baa spread for the five days prior to the FOMC meeting[10]. I denote the associated regression coefficient by δ. Since forecasts for house prices are not provided in the Greenbook[11], my instrument is instead Δh_m^{2M}, the 3-month moving average of monthly growth in the real house price index, for the 2 months prior to the FOMC meeting m. ψ is the regression coefficient associated with the house prices.

The house price index (HPI)[12] is published by the FHFA (Federal Housing Finance Agency). The HPI is a weighted repeat sales index, which measures average price changes in repeat sales for the value of single-family homes, or refinancing of the same properties, and weights them. The HPI data are nominal so I deflate the data using headline CPI inflation at meeting m. It should be noted that house price data are generally released with a lag of 2-3 months. For example, the FHFA published the November 2020 HPI report on January 26, 2021, and the January 2021 data on March 30, 2021. Therefore, the monetary authorities have to make predictions based on information about house prices two to three months ago, no matter how early. This can be seen in more detail by looking at the transcript of each FOMC meeting and the transcript forecast (as shown in Figure A.4 in Appendix). To reflect this, the 3-month moving average of house price growth[13] for the 2 months prior to the meeting are included in the equation. According to equation (2), I build four different types of monthly[14] monetary policy shocks: (I) for the conventional specification by Romer and Romer (2004), (II) for shifts to the policy rate that additionally control for the central bank's concern regarding credit costs, (III) for shifts to the policy rate that control for the house prices, and (IV) for shifts to the policy rate that control for both credit spreads and the house prices at the time of the FOMC meeting. The results from these four different versions of regression (2) are reported in Table 3.

[10]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.

[11]While Greenbook forecasts for house prices had been used in several meetings, (e.g. the Greenbook forecast for house prices was shown graphically based on the staff projection in the FOMC meeting on March 2006. See Figure A.4 in Appendix), the numerical data are not yet available to the public.

[12]This price information is obtained from repeat mortgage transactions since January 1975 on single-family properties whose mortgages have been purchased or securitized by Fannie Mae or Freddie Mac.

[13]Results are robust to using the real house price changes for the 2 months, 3 months, and 4 months prior to the meeting.

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

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

	[1]	[2]	[3]	[4]
Old Target	-0.0732***	-0.109***	-0.0917***	-0.116***
	[0.0213]	[0.0220]	[0.0226]	[0.0231]
Credit Spreads		-0.162***		-0.132***
		[0.0394]		[0.0368]
House Prices			0.250**	0.198*
			[0.111]	[0.110]
Forecasts				
Unemployment				
h = 0	-0.0760**	-0.101***	-0.0965***	-0.111***
	[0.0319]	[0.0294]	[0.0322]	[0.0305]
Output				
h = -1	0.0366**	0.0221	0.0411**	0.0285*
	[0.0156]	[0.0139]	[0.0161]	[0.0153]
h = 0	0.0735***	0.0603***	0.0685***	0.0604**
	[0.0219]	[0.0222]	[0.0240]	[0.0237]
h = 1	0.0216	0.00487	0.00927	-0.00302
	[0.0243]	[0.0250]	[0.0241]	[0.0250]
h = 2	0.0172	0.0146	0.00127	0.00132
	[0.0269]	[0.0265]	[0.0245]	[0.0246]
Inflation				
h = -1	0.0257	0.0194	0.0345	0.0286
	[0.0209]	[0.0204]	[0.0213]	[0.0209]
h = 0	0.0359	0.0427*	0.0539*	0.0539*
	[0.0273]	[0.0254]	[0.0284]	[0.0275]
h = 1	0.0688	0.0632	0.0870	0.0785
	[0.0693]	[0.0651]	[0.0684]	[0.0666]
h = 2	0.167**	0.126*	0.214***	0.168**
	[0.0738]	[0.0725]	[0.0809]	[0.0808]
Forecasts Revisions				
Output				
h = -1	-0.0256	-0.0141	-0.0220	-0.0133
	[0.0271]	[0.0250]	[0.0259]	[0.0249]
h = 0	0.0145	-0.00414	0.0184	0.00139
	[0.0321]	[0.0298]	[0.0329]	[0.0316]
h = 1	0.0563	0.0510	0.0688*	0.0640*
	[0.0366]	[0.0338]	[0.0367]	[0.0355]
h = 2	0.0411	0.0110	0.0312	0.00665
	[0.0610]	[0.0567]	[0.0556]	[0.0529]
Inflation				
h = -1	0.000661	0.00501	0.00636	0.0105
	[0.0944]	[0.0880]	[0.0953]	[0.0926]
h = 0	-0.0623	-0.0515	-0.0681	-0.0561
	[0.115]	[0.107]	[0.115]	[0.111]
h = 1	-0.0310	-0.0361	-0.0322	-0.0362
	[0.0545]	[0.0495]	[0.0440]	[0.0423]
h = 2	-0.0466	-0.0622*	-0.0619**	-0.0703**
	[0.0288]	[0.0315]	[0.0269]	[0.0274]
Observations	144	144	142	142
Adj. R-squared	0.515	0.566	0.561	0.593

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

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 terms of inflation and unemployment. The regression is run at a 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. This result suggests that output and inflation forecasts have significant and positive coefficients. Moreover, unemployment forecasts have a negative coefficient with a small standard error. In line with the results reported by Romer and Romer (2004), Coibion and Gorodnichenko (2011), and Cloyne and Hürtgen (2016), the estimation result implies 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, there is no 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 the version of regression (2) that includes the average Baa spread for the five days prior[15] to the FOMC meeting over the same sample period. The estimated coefficients of the changes in the intended funds rate over Greenbook forecasts and revisions are similar to those in column [1]. Notably, I find that the central bank reacts to changes in the Baa corporate credit spreads beyond the information contained in the Greenbook forecasts 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 Romer and Romer shocks are affected by the endogenous response of monetary policy to changes in credit spreads.

The third column [3] of Table 3 reports the estimated coefficients for the version of regression (2) that includes the 3-month moving average of monthly growth in the real house price index for the 2 months prior to the meeting. The estimated coefficients of the changes in the intended funds rate over Greenbook forecasts and revisions are similar to the results shown in columns [1] and [2]. Further, the results show clear evidence that the U.S. monetary authority systematically responded to changes in real house prices by weighting them with positive values for the Great Moderation period. This is in line with the findings by Aastveit et al. (2017), who show that the Fed has on average responded to fluctuations in house prices and that this response has on average been quantitatively important. The coefficient ψ has a point estimate of 0.25 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 a rise in the intended Federal funds rate.

Lastly, column [4] in Table 3 reports the estimation result for the version of regression (2) that contains both credit spreads and house prices. In line with the previous results reported in

[15] The associated results are robust to using the average Baa spread calculated from the ten days prior to the meeting.

columns [1] to [3], the estimated coefficients provide evidence that the monetary authority tends to endogenously respond to the current economic conditions and its outlooks (output, unemployment, and inflation forecasts, and those revisions). The estimated coefficient δ, which is associated with credit spreads, has a point estimate of -0.12, and the estimated coefficient ψ, which is associated with house prices, has a estimate of 0.2 with small standard errors[16], with an R^2 that is a bit higher. Overall, the results in Table 3 confirm that the conventional estimates of the Romer and Romer shocks are affected by the endogenous response of monetary policy to changes in credit spreads and house prices, simultaneously[17].

Further, the estimated residuals of the four specifications in regression (2) shown in Table 3 constitute four different versions of narrative-based measures for monetary policy shocks. Here, I denote those as follows: (I) "RR," the conventional Romer and Romer (2004) monetary policy shocks; (II) "RR+CS," adjusted monetary policy shocks which are constructed by controlling for the Baa corporate credit spreads in the regression; (III) "RR+HP," adjusted monetary policy shocks which are constructed by controlling for the 3-month moving average of real house price growth in the regression; and (IV) "RR+CS+HP," fully-adjusted monetary policy shocks which are constructed by controlling for both credit spreads and house prices in the regression. Though the shocks are highly correlated (0.91 on average) with each other, they lead to dramatically different implications about monetary policy, as I show in the next section.

Taking stock of this numerical evidence, I empirically document two testable implications for the results of the textual analysis of the FOMC transcripts discussed in Section 2. In particular, I proceed in two steps. First, I construct a measure of distance to show the numerical differences caused by credit spreads from the residuals of the regression shown in Table 3, by applying a simple Euclidean distance formula. I use the following specification:

$$D[RR,\ RR{+}CS] = \sqrt{([RR] - [RR{+}CS])^2} * 100 \tag{3}$$

$$D[RR{+}HP,\ RR{+}CS{+}HP] = \sqrt{([RR{+}HP] - [RR{+}CS{+}HP])^2} * 100 \tag{4}$$

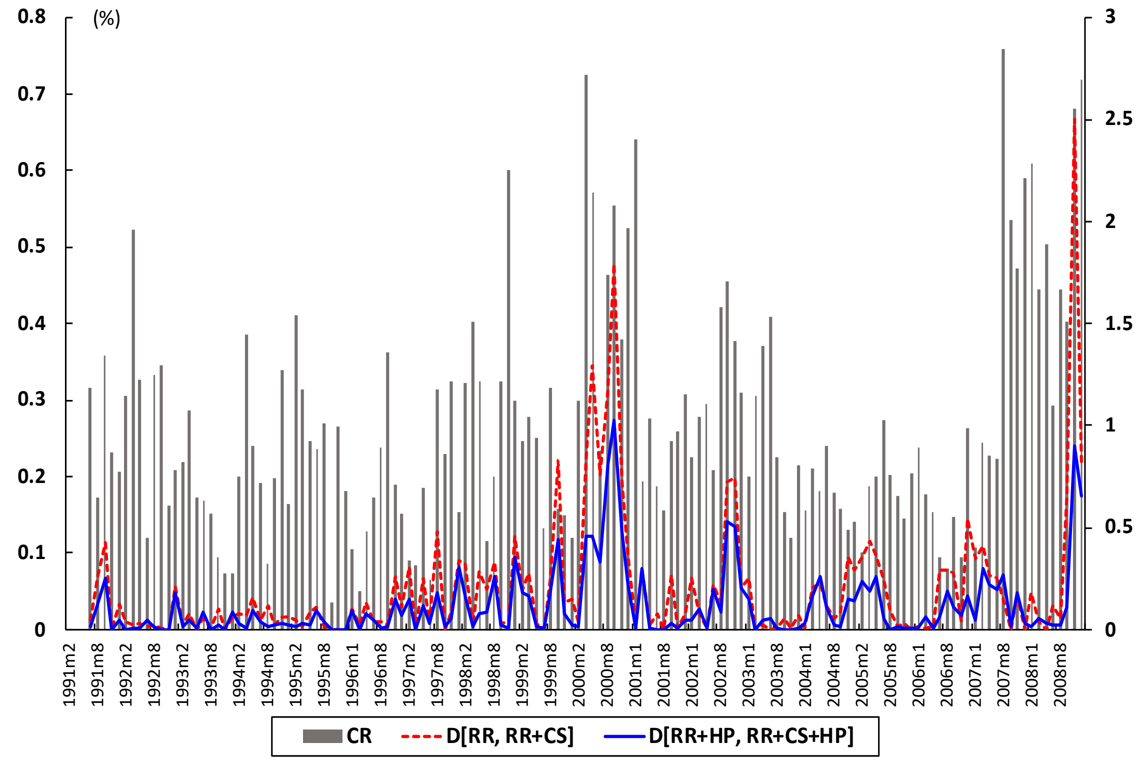
Both indicators, $D[RR,\ RR{+}CS]$ and $D[RR{+}HP,\ RR{+}CS{+}HP]$, imply that those values are positive if one should not consider credit spreads to identify the monetary policy shocks in terms of narrative approach. Further, both indicators are compatible with the results of the textual analysis, which reflects the frequency of terms that are associated with the credit market, as discussed in Section 2. To make the comparison easier, the size of distances are rescaled by multiplying them by 100.

Figure 4 reports the test for correlation with the frequency of word counts in the credit group

[16] Aastveit et al. (2017) find that the estimated coefficient associated with real house price growth is significant and roughly equal to 0.1, using a structural VAR model with a time-varying parameters model. They describe how such a response to house prices is estimated over most of their sample, 1975 Q2 to 2008 Q4, on a quarterly basis, with the important exception of the second part of the 1990s.

[17] See the Appendix B, which provides related evidence on the exogeneity of house prices using High-Frequency instrument for monetary policy surprises.

Figure 4: Implications for credit spreads: word search and distances



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

(a list that contains terms related to credit market performances) and the numerical distance that can occur if changes in corporate spreads are not taken into account when estimating the narrative-based monetary policy shocks. The shaded bars in Figure 4 depict the frequency (%) of word counts related to credit market performances over the total terms expressed in transcripts for each FOMC meeting over the sample period from July 1991 to December 2008. The black dashed line, *D[RR, RR+CS]*, refers to rescaled Euclidean distances between "RR" and "RR+CS," and the blue solid line, *D[RR+HP, RR+CS+HP]*, shows the rescaled distances between "RR+HP" and "RR+CS+HP". Notably, I document that the values of both distance indicators are caused when one does not control for the systematic responses of monetary policy shocks to changes in corporate spreads. Two remarkable results can be found in Figure 4. First, the movements in each distance line are very similar to each other over the sample period, which implies that the differences can be due to credit spreads. Second, the two distance indicators and the word search results of textual analysis for the credit group in Section 2 have a higher relationship. Indeed, the correlation between CR and those distances depicted in Figure 4 is around 0.4 to 0.45. This can imply that the narrative evidence, based on textual analysis using FOMC transcripts, is consistent with the numerical results estimated through the reconstructed Romer and Romer (2004) estimation. Thus, both approaches provide 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 performance[18].

In a same manner, I build another measure of distance to further assess the numerical differences caused by house prices from the estimated residuals of the regression shown in Table 3. Specifically:

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

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

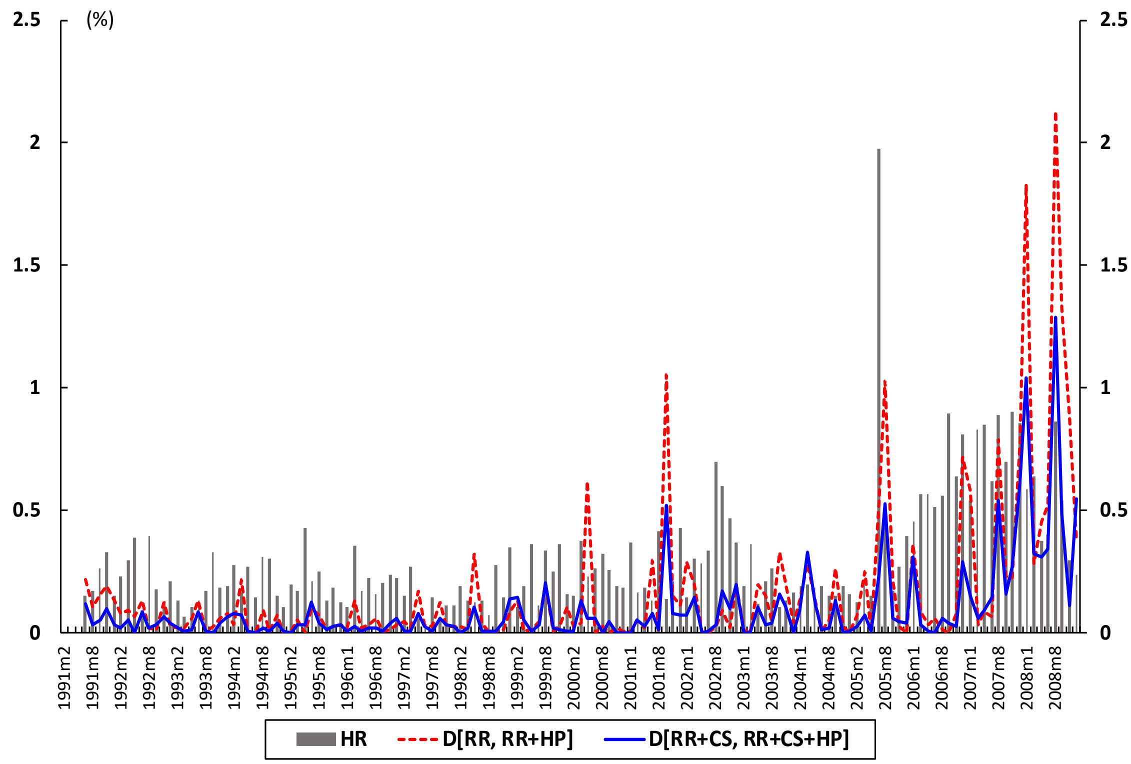
Equations (5) and (6) illustrate the distances of the Romer and Romer shocks which originate by house prices for their shock construction. Similarly, both indicators are compatible with the results of textual analysis, which reflect the frequency of terms associated with the housing market, as discussed in Section 2.

Figure 5 reports the test for correlation with the frequency of word counts in the housing group (a list that contains terms related to the housing market) and the numerical distance that can be created if changes in house prices are not taken into account when estimating the narrative-based monetary policy shocks. The shaded bars in Figure 5 depict the frequency (%) of word counts related to the housing market over the total terms expressed in transcripts for each FOMC meeting over the same sample period. The black dashed line, *D[RR, RR+HP]*, refers to rescaled Euclidean distances between "RR" and "RR+HP," and the blue solid line, *D[RR+CS, RR+CS+HP]*, shows the rescaled distances between "RR+CS" and "RR+CS+HP". Both distance indicators are positive values when one does not control for the endogenous reactions of monetary policy shocks to changes in house prices. In Figure 5, similarly, the trends in each distance line are comparable, implying that the disparities can be due to house prices. Moreover, the two distance indicators and the word search results of textual analysis for the housing group in Section 2 have a close relationship. Indeed, the correlation between HR and those distances, as illustrated in Figure 4, is around 0.42. Thus, the narrative evidence based on textual analysis and the subsequent numerical results provide clear evidence that the effects of monetary policy shocks depend on the presence of a systematic response of monetary policy to the housing market.

Lastly, I define a measure of distance to show the numerical differences caused by both house prices and credit spreads from the estimated residuals of the regression shown in Table 3, specifically

[18] There are several ways to measure distance indicators, such as using a square function or an absolute function of the difference between two distinct points. Nevertheless, the correlations are robust to using these other methods.

Figure 5: Implication for house prices: word search and distances



Note: Shaded bars (CR+HR) denote the share (%) of word counts related to housing and financial markets over the total terms expressed in the transcripts for each FOMC meeting from July 1991 to December 2008. The share rates are plotted on the left axis. The re-scaled Euclidean distances in residuals are plotted on the right axis; the Blue-Solid line is for "RR" and "RR+CS+HP."

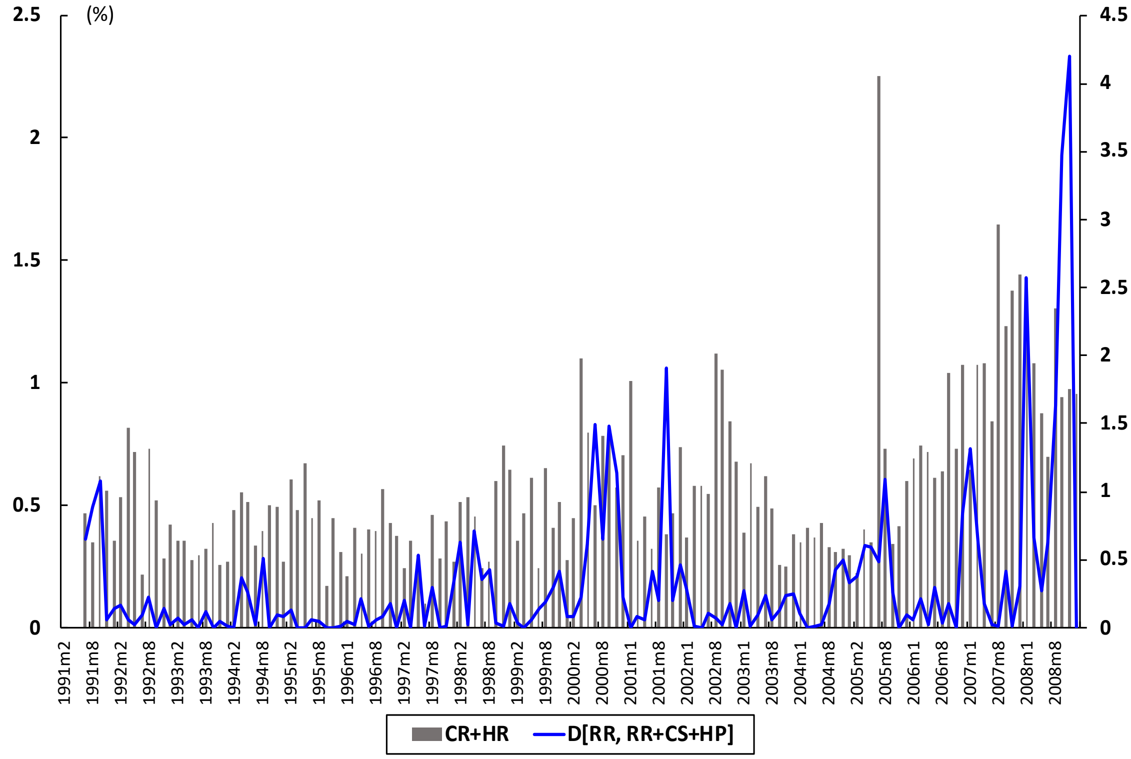
the distance between the first and last columns, applying the same formula. I use the following specification:

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

The equation (7) indicates the distances of the Romer and Romer shocks which are caused by both house prices and credit spreads for their shock identification. Again, the indicator is compatible with the word search, which reflects the frequency of terms that are associated with housing and credit markets, as discussed in Section 2.

In Figure 6, I repeat the test for correlation with the frequency of word counts in both groups (housing + credit), a set of lists that contains all terms related to housing and credit markets, and the distance that can occur if changes in house prices and corporate spreads are not taken into

Figure 6: Implications for house prices and credit spreads: word search and distances



Note: Shaded bars (CR+HR) denote the frequency (%) of word counts related to both housing and credit markets over the total terms expressed in the transcripts for each FOMC meeting from July 1991 to December 2008. The rates of frequency are plotted on the left axis. The re-scaled Euclidean distances in residuals are plotted on the right axis; the Blue-Solid line is for "RR" and "RR+CS+HP."

account. The shaded bars in Figure 6 depict the frequency (%) of word counts over the sample period from July 1991 to December 2008. The blue solid line, *D[RR, RR+CS+HP]*, shows the rescaled distances between "RR" and "RR+CS+HP." The associated results are almost identical with those described in Figure 4 and Figure 5. Particularly, *D[RR, RR+CS+HP]* and the word search results for "CR+HR" have a higher relationship and both follow a similar pattern. The correlation between these two indexes is around 0.39, which implies that the narrative evidence based on textual analysis is consistent with the numerical result estimated. Consequently, both approaches provide empirical evidence that the effects of monetary policy shocks rely on the presence of a systematic response of monetary policy to not only credit spreads but also house prices.

From a technical point of view, if one doesn't control for elements that can systematically affect monetary policy shocks, this identification strategy 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 that sense, my view is that the evidence in Section 3 most strongly supports the fact that house prices and corporate credit spreads are critical components in the monetary authority's information set. What matters is that the conventional narrative-based monetary policy shocks are correlated with house prices and credit spreads, which has important implications for estimating monetary policy transmission to the real macroeconomic variables using these shocks. This is what I turn to next.

4 Econometric Methodology

In conventional wisdom, the study of dynamic causal inference of monetary policy can be divided into two steps. The first would be identifying exogenous (and unexpected) variation in monetary policy, which I discussed in detail in Section 3. My results there imply that traditional narrative-based monetary policy shocks are correlated with house prices and credit spreads. From this point of view, I propose a novel measure of monetary policy shocks that controls for house prices and corporate credit spreads by re-building the original Romer and Romer (2004) estimation framework, then compare the estimates to those obtained for conventional measure of monetary policy shocks.

The second step delivers the impulse response functions estimated for the policy shocks given by the first step. Hence, I now investigate to what extent the narrative identification of the effects of monetary policy shocks in structural VARs (SVARs) and local projections are affected by these correlation, along with my proposed correction. I begin, in Section 4.1, by laying out the basic local projections similar to those in Ramey (2016). In Section 4.2 I first document a standard SVARs and consider the alternative estimation method of Plagborg-Møller and Wolf (2021), which uses a recursive SVAR with the monetary policy shock ordered first, the model typically used to track the effects of policy shocks using external instruments.

4.1 Local Projections

Jorda (2005) local projection is an approach to estimate the dynamic effects of a monetary policy shock. The idea is to directly regress future values of macroeconomic variables on the identified monetary policy shock, with controls for lags and other relevant macroeconomic variables. When the monetary policy shock is observed, I can perform the local projections regressions. Based on the four series of residuals from the regressions shown in Table 3, I estimate the specified macroeconomic variables directly at horizon $t+h$ on the shock in period t, to construct impulse responses. 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 $h = 0, 1, ..., H$,

$$y_{j,t+h} = \alpha_h + \beta_{j,h} e_{i,t} + \psi_{j,h}(L) z_t + \varepsilon_{j,t+h} \tag{8}$$

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 one of the identified monetary shocks 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 real industrial production (IP), the unemployment rate, the consumer price index (CPI), real durable/non-durable consumption indexes, the real house price index[19], the average 10-Year Baa corporate credit spread, and the Federal funds rate[20]. Variables enter the specification in log levels, with the exception of interest rates and credit spreads. By keeping the composition of the variables of interest fixed across the four specifications, I can assess the differences in the impulse response functions as an indication of the shocks constructed under different identification strategies. 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[21]. 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, log of commodity prices, and 1-year treasury constant maturity rates. Most of the relevant data can be obtained from the Federal Reserve Bank of St Louis database (FRED) and the 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.

4.2 Standard SVARs

Consider the following VAR, written in structural form:

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

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

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

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

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 rows 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 the 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 a systematic component of monetary policy. In turn, to characterize that shock, 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 (Σ, Φ), that is, the likelihood of the SVAR model (9) exists 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 also discussed in CEE (1999) and 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.

Plagborg-Møller and Wolf (2021) (henceforth, PMW) recommend a procedure for estimating impulse response functions using an external instrument, which they call the "internal instrument" approach. They suggest including the instrument in the VAR, ordering it first, and using recursive (Cholesky) ordering to estimate its effects. Intuitively, this allows the other variables in the VAR to respond to the instrument on impact, while the dynamics are asymptotically the same (in population and for infinite lag length) as a conventional VAR or LP-IV estimation. As discussed in Section 3, the residuals of the four regressions shown in Table 3 constitute narrative-based measures of monetary policy shocks. Here I rebuild the estimates of PMW, which I will call Hybrid-SVARs, using my new series of shocks based on the narrative identification I discussed.

Typically, 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, instead of substituting the narrative shocks for the Federal funds rate, I use the PMW version, a monthly VAR with a fixed composition of variables, to trace the effects of each identified monetary policy shock in the estimation system. This specification uses the recursive assumption, placing the narrative policy shock first, followed by the Federal funds rate, the log of real industrial production, the unemployment rate, the log of prices, and the log of commodity prices, thus assuming that the monetary shock can have an impact on the macroeconomic variables within a month but not vice versa.

5 The Dynamic Causal Inference of Monetary Policy

Section 5 applies my new measure to reassess previous empirical estimates of the effects of monetary policy on the macroeconomics. I begin my empirical reassessment of the transmission of monetary policy with the shocks that control for the endogenous reactions of monetary innovations to house prices and credit costs. In Section 5.1, I estimate the local projections and in Section 5.2, I revisit Hybrid-SVARs to estimate the impulse response functions of real economic variables, equipped with the new measures of exogenous variation in the monetary policy shocks. In each section, the estimation is run on a monthly basis for the sample period January 1991 through December 2008, with three variants of the specification: the first excludes both credit spreads and house prices from the standard Romer and Romer (2004) equation, in the second varient monetary shocks are estimated by imposing that the target rates endogenously react to changes in credit spreads, and the last variant includes both credit spreads and house prices in the identification of monetary policy shocks.

5.1 Results from Local Projection

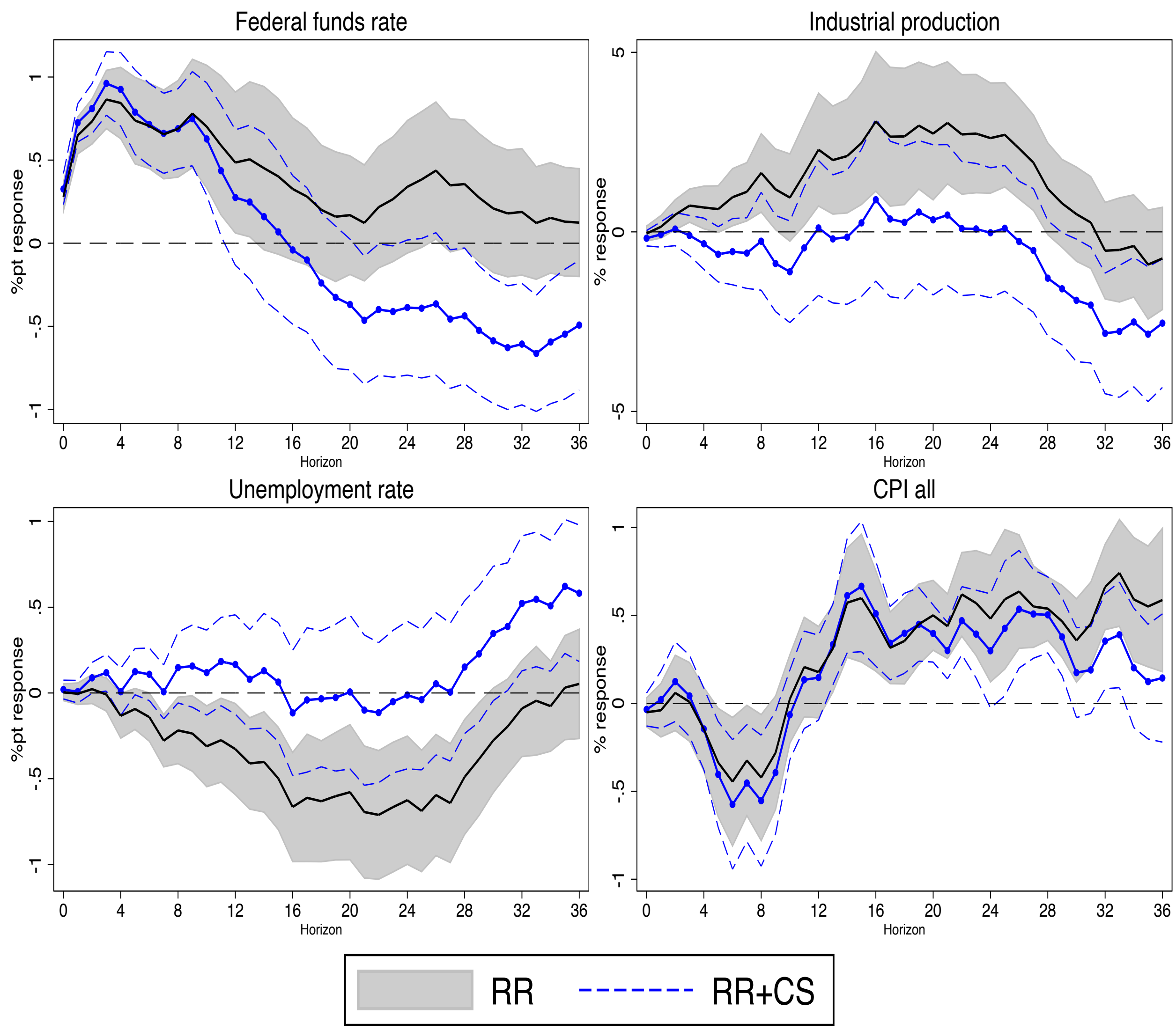
The estimation results are presented in Figures 7 through 9. Figure 7 reports impulse response functions to a monetary policy shock estimated using local projections that encompass two different identifications, "RR" and "RR+CS," over the sample from Jan. 1991 through Dec. 2008. The solid black line in each panel depicts the impulse response function of the specified variable (Federal funds rate, real industrial production, the unemployment rate, and headline CPI) to a 1 percentage point change in monetary policy shock identified in the original R&R (2004) equation. The blue dotted line in each panel depicts the impulse response of the specified variable to a 1 percentage point change in monetary policy shock identified in the R&R (2004) equation with Baa corporate credit spreads, using the "RR+CS" shocks as the policy variable. Shaded bands and blue dashed lines report the associated 68% confidence intervals around those point estimates.

For the baseline specification (solid black line), the near-term effect of the 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 three years. The shock elicits expansionary effects on real industrial production, consumption, and unemployment, hence delivering 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 16 months later. The unemployment rate falls and reaches the bottom around 24 months later. Both industrial production and the unemployment rate gradually head back toward steady state after 32 months. The response of house prices and credit spreads are likewise not consistent with the standard monetary theory. The CPI is affected over the first year in a contractionary way, although it rises over a longer horizon on ward. Overall, the results from using baseline R&R shock as an instrument for monetary policy in Figure 7 echo Ramey (2016), who finds no evidence of the contractionary effects of monetary policy during the Great Moderation. Hence, the use of the conventional R&R instrument triggers real activity puzzles and price puzzles over a longer horizon, implying that conventional estimates of the effects of monetary policy on the macroeconomy, using narrative identification, are substantially biased due to the endogeneity of the monetary policy shocks.

One possible explanation for the odd features of the impulse responses shown in Figure 7 is that mis-identification of the policy shock is distorting the estimated impulse responses. Caldara and Herbst (2019) argue that a systematic component of monetary policy is crucially characterized by a direct reaction to changes in corporate credit spreads. They show that monetary policy shocks, identified using Bayesian proxy SVARs, that include corporate spreads have large economic effects compared to shocks identified using conventional SVAR identification schemes. The second regression model employs corporate credit spreads in the estimation framework to assess their findings. Indeed, the results imply that the propagation of monetary policy shocks to real economic

[22]These results echo those of Barakchian and Crowe (2013) and Ramey (2016), who show that the leading specifications imply expansionary effects in the sample from 1988 through 2007; contractionary monetary policy shocks appear to be expansionary.

Figure 7: IRFs to monetary policy shocks: “RR” and “RR+CS”



Note: The solid black line in each panel depicts the impulse response of the specified variable (Federal funds rate, real industrial production, the unemployment rate, and headline CPI) to 1 percentage point changes in monetary policy shock identified in the R&R (2004) equation. The blue dotted line in each panel depicts the impulse response of the specified variable to 1 percentage point changes in monetary policy shock identified in the R&R (2004) equation with Baa corporate credit spreads, using the “RR+CS” shocks as the policy variable. Shaded bands and blue dashed lines denote the associated 68% confidence intervals. Sample: 1991:1 - 2008:12.

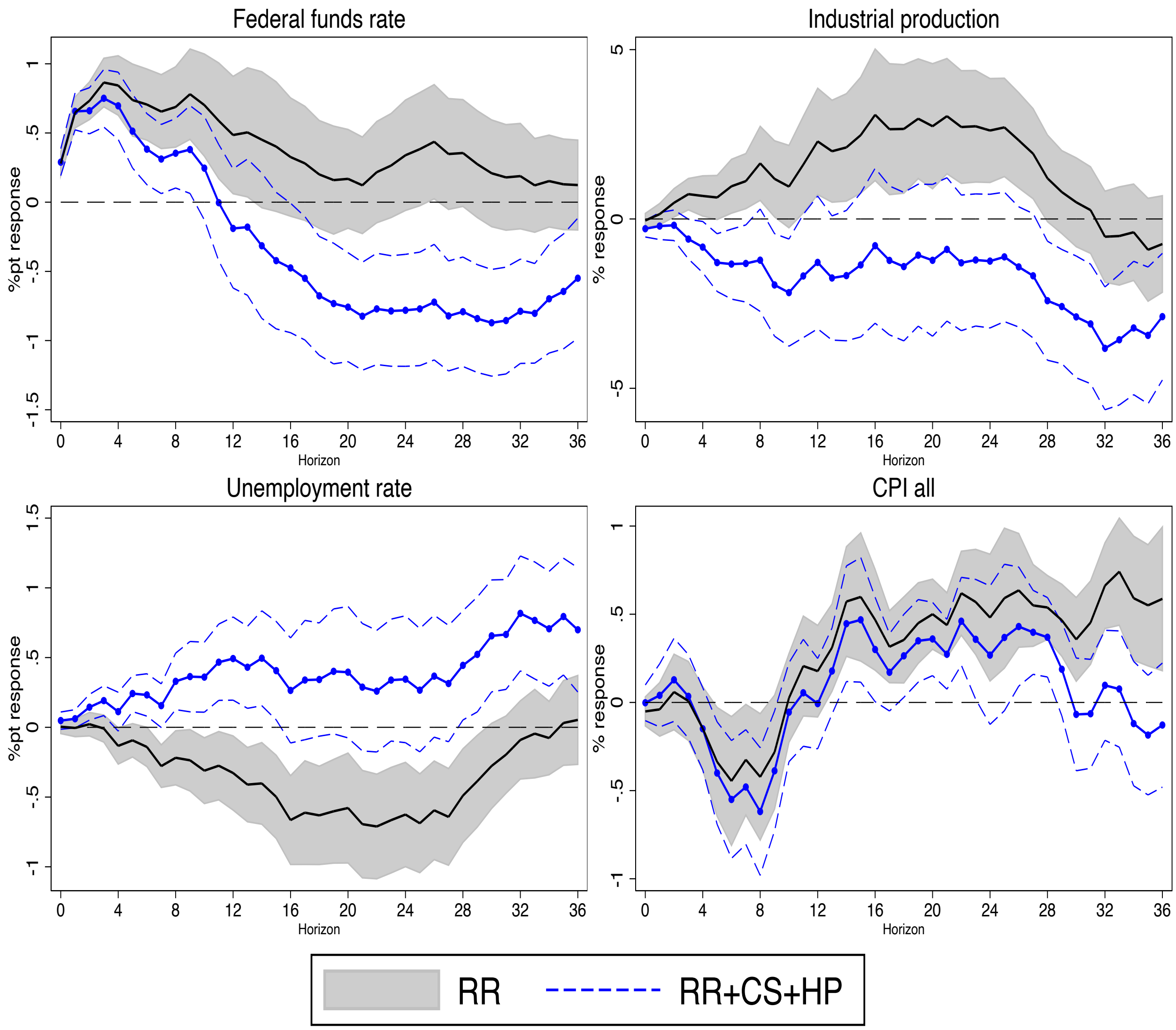
variables depends on the presence of a systematic response of monetary policy to credit spreads. In the case of an RR+CS shock (blue dotted line), the impact (near-term) responses of the Federal funds rate, industrial production, the unemployment rate, consumption, and prices are nearly identical to those in the case of baseline specification. In contrast, the two identifications display different dynamics. The Federal funds rate rises quickly after the shock and turns negative after about one and a half years, which implies that monetary policy becomes more accommodative relative to its initial level. This is intuitive if we think of economic data as being persistent, so that the Fed's response to that data leads to an upwardly biased estimate of interest rate persistence. This change in monetary policy stance also can be explained by inspecting the real and financial consequences of the shock.

Overall, the second model shows that the shocks constructed after controlling for corporate credit spreads do not give rise to puzzles on real activity but induce no statistically significant changes in real economic variables under the 68% confidence interval. This can imply that a systematic component other than corporate credit spreads can explain the endogenous response of monetary policy rules. However, the key point to take away from Figure 7 is that using narrative policy shocks identified with credit spreads is crucial for understanding the direction of propagation of policy innovations during the Great-Moderation period.

I now turn to the main research questions of this paper: How much difference does controlling for the endogenous response of monetary policy shocks to house prices make for estimating the effects of monetary policy on the economy? Figure 8 provides an answer to this question. In particular, the associated results imply that the direction and size effects of monetary policy shocks on the real economy depend on the presence of a strong systematic response of monetary policy to real house prices and credit costs. Figure 8 reports impulse response functions to monetary policy shocks by estimating local projections that encompass the two identification strategies, "RR" and "RR+CS+HP," over the sample from Jan. 1991 through Dec. 2008. The solid black lines report the baseline results, which are identical response functions of each variable I discussed in Figure 7. The blue dotted line in each panel in Figure 8 depicts the impulse response functions of the Federal funds rate, real industrial production, the unemployment rate, and the aggregate price index to the identified monetary shocks with house prices and credit spreads, using the "RR+CS+HP" shocks as the policy variable.

The first key point to note in Figure 8 is that, in contrast with the results in Figure 7, the real activity puzzles become less pronounced, with statistically significant estimates and long-lasting responses, when using my improved measure of monetary policy shocks constructed by controlling for both house prices and credit spreads. Industrial production and consumption fall on impact and they are significantly persistent over the sample period. The unemployment rate rises on impact, with theoretically consistent results. Two years after the shock, output has fallen by about 1 percent and the unemployment rate has increased by about 0.5 percent. Interestingly, the real house prices drop significantly on impact and contract persistently. These results align with those that Iacoviello (2005) and Del Negro and Otrok (2008) obtained earlier. In addition, the exercise supports the empirical finding that a contractionary monetary policy shock causes a sudden tightening in financial conditions, with Baa credit spreads significantly increasing on impact, as discussed in Gertler and Karadi (2015), Peek, Rosengren, and Tootell (2016), and Caldara and Herbst (2019).

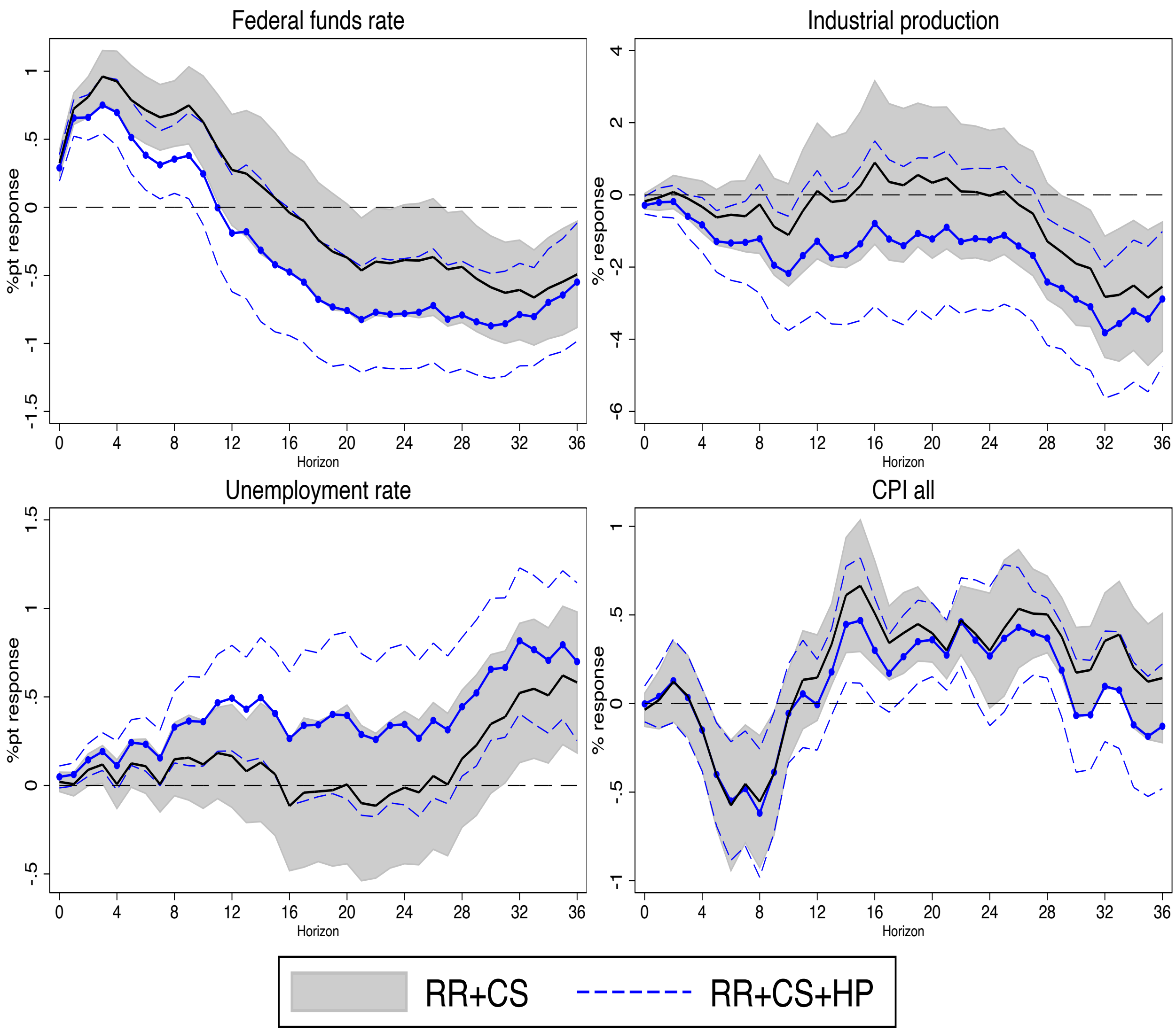
Figure 8: IRFs to monetary policy shocks: "RR" and "RR+CS+HP"



Note: The solid black line in each panel depicts the impulse response of the specified variable (Federal funds rate, real industrial production, the unemployment rate, and headline CPI) to 1 percentage point changes in monetary policy shocks identified in the R&R (2004) equation. The blue dotted line in each panel depicts the impulse response of the specified variable to 1 percentage point changes in monetary policy shocks 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 68% confidence intervals. Sample 1991:1 - 2008:12.

The second key point to take away from Figure 8 is that the differences in the blue dotted lines in both Figure 7 and Figure 8 provide important implications on how the attenuation occurs in the magnitude of monetary policy shocks to economic fluctuations, when the shocks are not identified with real house prices. By embracing all the implications of the empirical results in Figures 7 and 8, and to find out the potential role of house prices in the identification strategy of monetary policy shocks, I finally investigate impulse response functions to monetary policy shocks by estimating local projections that encompass the two identification strategies, "RR+CS" and "RR+CS+HP," over the same sample period. The solid black line in each panel in Figure 9 illustrates the response

Figure 9: IRFs to monetary policy shocks: "RR+CS" and "RR+CS+HP"



The solid black line in each panel depicts the impulse response of the specified variable (Federal funds rate, real industrial production, the unemployment rate, and headline CPI) to 1 percentage point changes in the monetary policy shocks identified in the R&R (2004) equation with Baa corporate spreads. The red dotted line in each panel depicts the impulse response of the specified variable to 1 percentage point changes in the monetary policy shocks 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 68% confidence intervals. Sample: 1991:1 - 2008:12.

functions of the Federal funds rate, real industrial production, the unemployment rate, and headline CPI to 1 percentage point changes in the monetary policy shocks identified in the R&R (2004) equation by controlling only Baa corporate spreads. On the other hand, the blue dotted line in each panel shows the response function of the variables to 1 percentage point changes in the monetary policy shocks 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. The results in Figure 9 provide supporting evidence that controlling for endogenous reactions of monetary policy to changes in house prices has a significant role in understanding the transmission of policy innovations to the macroeconomy. In Figure 9, the fully-adjusted monetary policy innovation shows a fall in output and a rise in unemployment rates significantly within two months, effects which are 30 percent larger than those in the second model.

Overall, the empirical results presented in Section 5.1 can be stylized in two aspects. The key implication of the analysis presented in this section is that models that do not embed 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 in Figures 7 through 9, this section provides the quantitative evidence 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 estimating local projections given external instruments. In addition, not only does the use of the identified instrument accounting for the credit spreads or house prices provide strong evidence, but the shocks identified by controlling for both credit spreads and house prices simultaneously shows response functions more consistent with standard macroeconomic theory. Further, these findings offer strong evidence that a contractionary monetary policy shock induces a contraction in output/consumption, a rise in unemployment/credit spreads, and a reduction in (house) prices. The most reasonable explanation for these finding is that both credit spreads and house prices are either conduits of changes in monetary policy to the real economy or important to quantifying the systematic response of monetary policy to economic conditions in both the financial and housing market, which are highly correlated to each other. Consequently, any model missing these interactions is likely to underestimate the effect of policy for business cycle analysis.

5.2 Results from Hybrid VAR

The empirical results from estimating local projections provide strong evidence of an interdependence between monetary policy and two systematic components, credit spreads and house prices. In particular, the findings discussed in Section 5.1 are primarily based on the heterogeneous responses of the real macroeconomic variables to changes in narrative monetary policy shocks across different identification strategies, using the local projection method. To ensure that the empirical results are not dependent on changes in estimation methodologies, Section 5.2 examines estimated responses with a hybrid approach by integrating the newly measured monetary policy shocks into standard VARs with the same composition of variables of interest. As discussed in Section 4.2, the specification uses the recursive assumption, placing the narrative shocks first in the ordering, followed by the Federal funds rate, output, unemployment, and the price index.

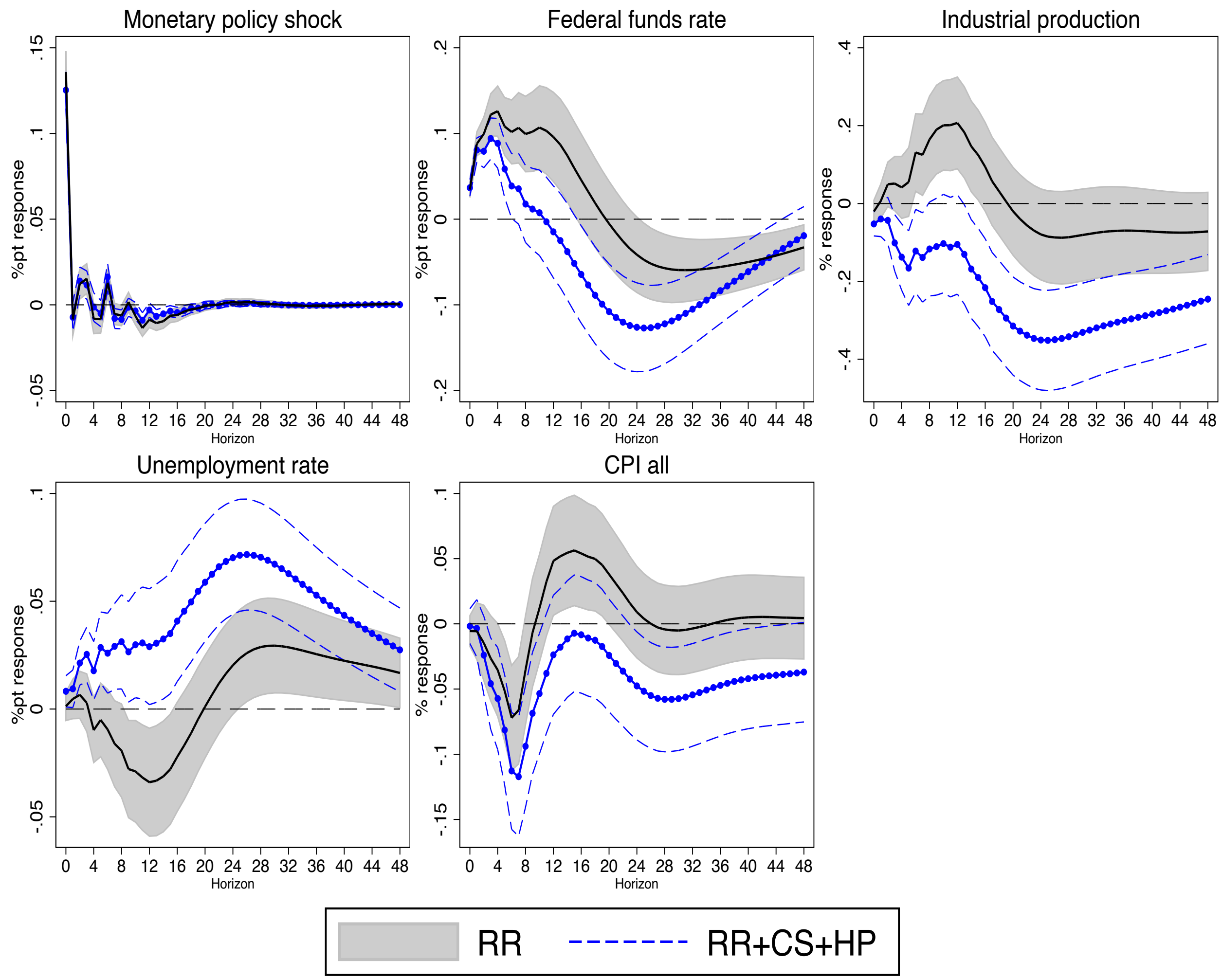
To show how monetary policy and real activity interact in Hybrid-VARs, I present empirical results from two models. I first estimate a five-equation Hybrid-VAR model that consists of the policy shock projected from the baseline specification; the Federal funds rate; the log of manufacturing industrial production; the unemployment rate; and a measure of prices, the log of the consumer price index [23]. The second model is also a five-equation Hybrid-VAR model that consists of the same specifications as the first model, except for the policy innovation, here the R&R narrative monetary policy shocks that controls for the systematic responses of monetary policy to both credit spreads and house prices. The regressions, which include a constant, are estimated on data from 1991 to 2008 using 6 lags.

The estimated results with Hybrid-VARs align with those in local projections. Figure 10 shows the dynamic impulse responses to monetary policy shocks using the Hybrid-VARs under the alternative identification strategies, "RR" and "RR+CS+HP.'. In each panel, the solid black line represents the impulse response of the variables of interest (policy shock, Federal funds rate, real industrial production, unemployment rate, and the headline consumer price index) to a 100 basis point deviation of the monetary policy shocks identified by applying the standard R&R equation. The blue dotted line in each panel depicts the impulse response of the specified variable to a 100 basis point deviation of the monetary policy shocks identified from the R&R equation with the components of Baa corporate spreads and real house prices. The shaded areas and red dashed bands denote the associated 68% confidence intervals, estimated over the sample period for 1991 to 2008. The baseline identification shows that a contractionary monetary policy shock induces a similar puzzle on real variables, in which industrial production rises and unemployment falls instantly. On the other hand, the new measure of policy shocks can account for many of the historical fluctuations at business cycle frequencies in production, employment, and inflation. The response of the real activities does not exhibit pronounced puzzles, which is theoretically consistent. Consequently, regardless of using different estimation methods, the empirical findings support the importance of incorporating house prices to understand the transmission of monetary policy shocks to the macroeconomy during the Great Moderation period.

I then show the further implications of this finding by estimating a five-equation Hybrid-VAR model that consists of the same specifications as the first model except for the policy instruments, with the RR shocks containing the systematic response of monetary policy to corporate credit spreads only. Figure 11 shows the impulse response functions of the variables of interest to monetary policy shocks using the Hybrid-VARs under the alternative identification strategies, "RR+CS" and "RR+CS+HP." In each panel, the solid black line represents the impulse response to a 100 basis point deviation of the monetary policy shocks identified by incorporating credit spreads into the

[23] Coibion (2012) substitutes the cumulative sum of monetary policy shocks in place of the Federal funds rate, but the selection of endogenous variables is similar to Coibion (2012) and Ramey (2016).

Figure 10: Hybrid-VARs - IRFs to monetary policy shocks: “RR” and “RR+CS+HP”

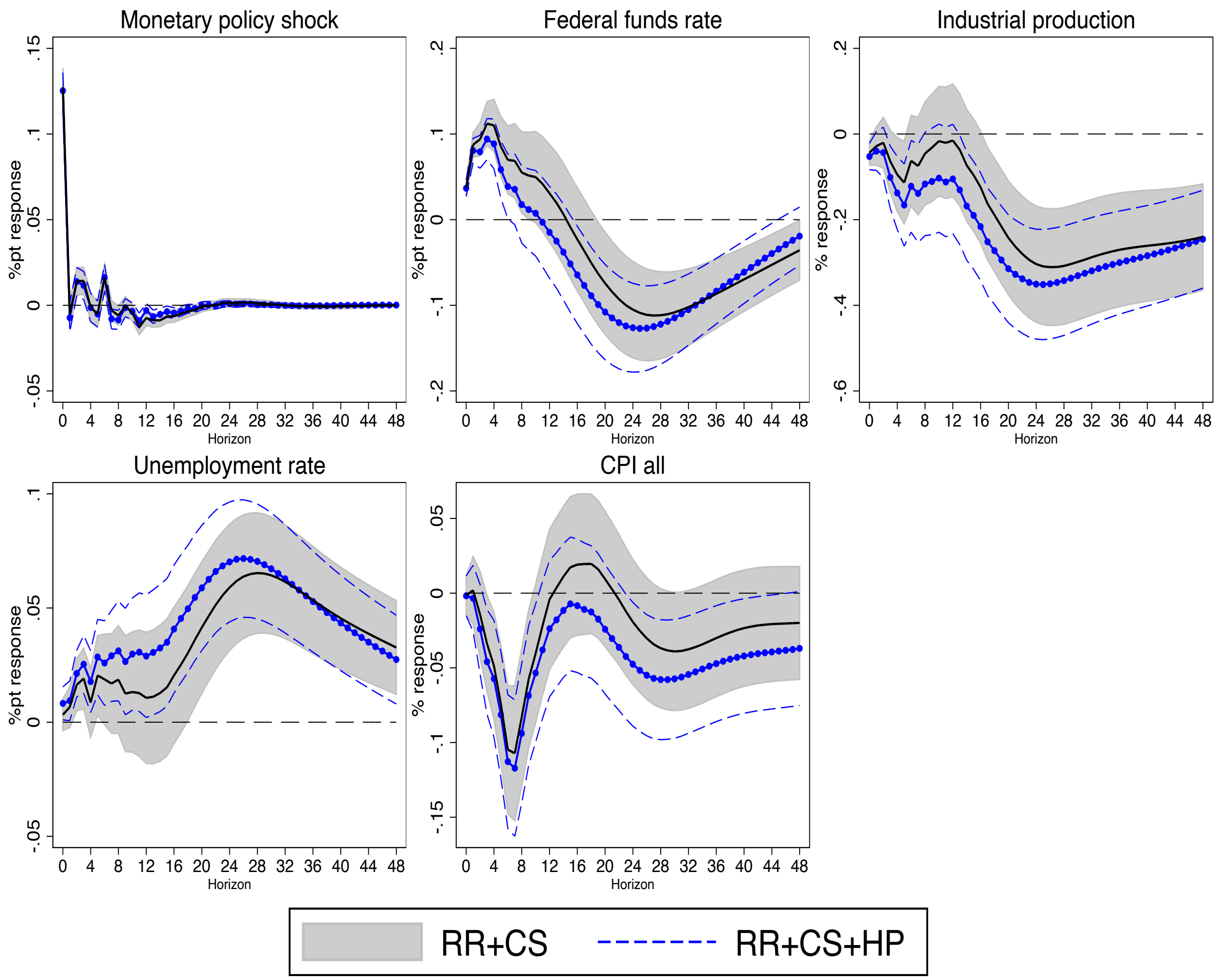


Note: The solid black line in each panel depicts the impulse response of the specified variable (policy shock, Federal funds rate, real industrial production, the unemployment rate, and headline CPI) to a 100 basis point deviation in the monetary policy shocks identified in the R&R (2004) equation. The blue dotted line in each panel depicts the impulse response of the specified variable to a 100 basis point deviation of the monetary policy shocks 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 68% bootstrap confidence intervals for the system estimated over the sample period, 1991:1 - 2008:12.

R&R (2004) equation. The blue dotted line in each panel depicts the impulse response of the specified variable to a 100 basis point deviation of the monetary policy shocks identified from the R&R equation with the components of Baa corporate spreads and real house prices. The shaded areas and blue dashed bands denote the associated 90% bootstrap confidence intervals for the system, estimated over the sample period of 1991 to 2008.

Overall, the estimated real effects of monetary policy shocks using Hybrid-VARs align with the

Figure 11: Alternative approach (Hybrid-VARs): Dynamic impulse responses to monetary policy shocks under different identifications, "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 a 100 basis point deviation of the monetary policy shocks identified using corporate spreads in the R&R (2004) equation. The blue dotted line in each panel depicts the impulse response of the specified variable to a 100 basis point deviation of the monetary policy shocks 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 blue dashed lines denote the associated 68% bootstrap confidence intervals for the system estimated over the sample period, 1991:1 - 2008:12.

local projection results. The baseline identification shows that a contractionary monetary policy shock induces a similar puzzle on real variables, in which industrial production rises and unemployment falls instantly. The response of the price level to the policy innovation is not significantly different from zero. On the other hand, the new measure of policy shocks can account for many of the historical fluctuations at business cycle frequencies in production, employment, and inflation. The response of the real activities does not exhibit pronounced puzzles, which is theoretically consistent. Consequently, regardless of using different estimation methods, the empirical findings support the importance of incorporating house prices to understand the transmission of monetary policy shocks to the macroeconomy during the Great Moderation period.

6 Conclusion

This paper revisits one of the fundamental questions of macroeconomics: Does monetary policy matter? It is a question that lies at the center of any model of short-run macroeconomic fluctuations. The discussion on the effects of monetary policy appears to be still controversial with a substantial degree of uncertainty, despite the numerous theoretical and methodological advances. Like so many empirical questions in economics, omitted variable bias is a central issue. If monetary policy matters, then it is vital to include a channel through which changes in aggregate demand have real effects. Both monetary policy actions and real economic activity are likely to be influenced by other variables. Anything that affects output-expectations, fiscal policy, financial stress - is also likely to drive decisions by the Fed.

Accordingly, a simple regression of output on an indicator of monetary policy would naively and incorrectly conclude that monetary policy would not have a significant effect on real economy. That is, if countercyclical monetary policy actions are common, the estimated impact of monetary policy will be biased toward zero. Specifically, not only the magnitude and significance but also the sign of the responses of economic variables such as output and prices rely on the given identification strategy, the details of the model specification, and the sample period. This paper helps rationalize these puzzling and inconsistent results by introducing house prices and credit spreads into the identification strategy, in terms of the narrative approach.

This paper provide a strong evidence that conventional estimates of the effects of monetary policy on the macroeconomy using narrative identification are substantially biased, due to the endogeneity of the monetary policy shocks. In particular, the direction and size effects of monetary policy shocks on the real economy depend on the presence of a strong systematic response of monetary policy to real house prices and credit costs. I find that monetary policy affects and endogenously reacts to house prices, at least for the Great Moderation period. Compared with conventional estimates, which often ignore the endogenous response of monetary policy to house prices, monetary policy shocks have a more prominent role in business cycle fluctuations. The empirical evidence shows that following a monetary tightening, production, unemployment, and prices contract, while lending and house prices cool down, which is in line with the standard theory of monetary policy. The effects are both sizable and persistent, suggesting that monetary policy is meaningful for both economic stabilization and financial stability. These findings are robust to a number of severe tests. It is important to stress that the dynamic responses of the real activities follow the standard theory of monetary policy, provided one includes house prices as well as credit spreads in the estimation system. These results imply that both are crucial conduits of changes in monetary policy to the real economy, as well as factors in quantifying the systematic response of monetary policy.

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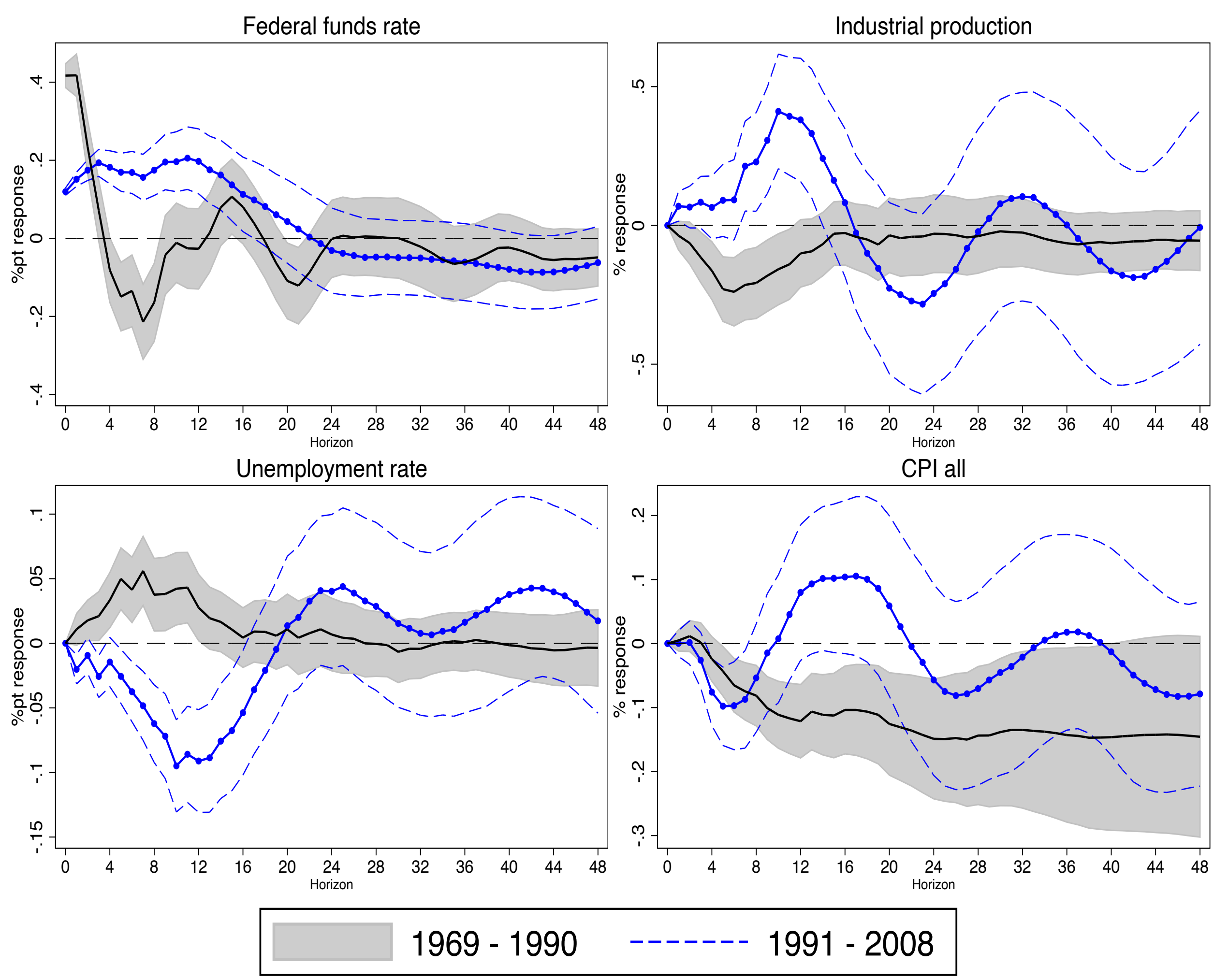
APPENDIX TO

Does the Federal Reserve respond to house prices?
Implications for monetary policy

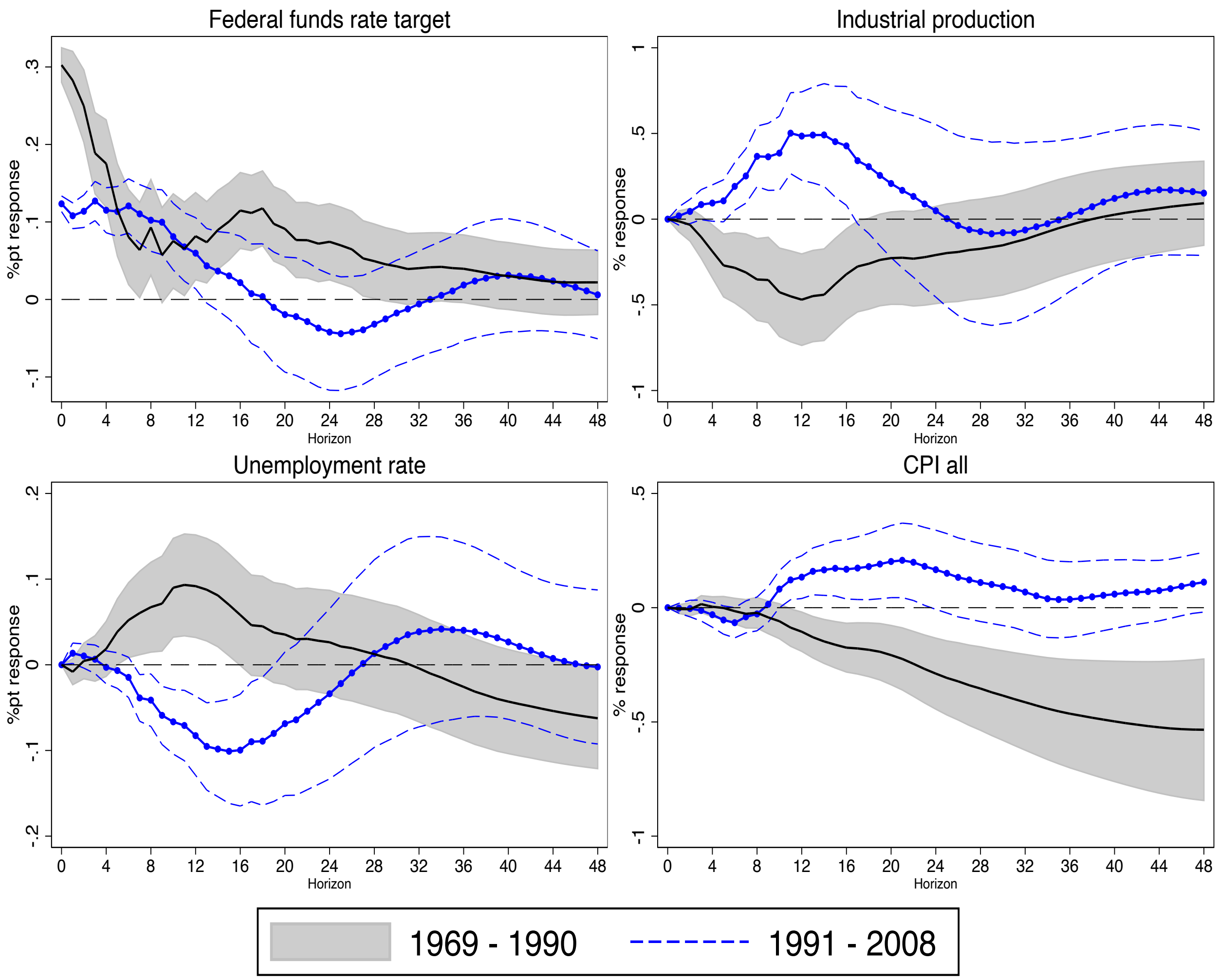
A Supplementary tables and figures

Figure A.1: Christiano et al. (1999): SVARs identification



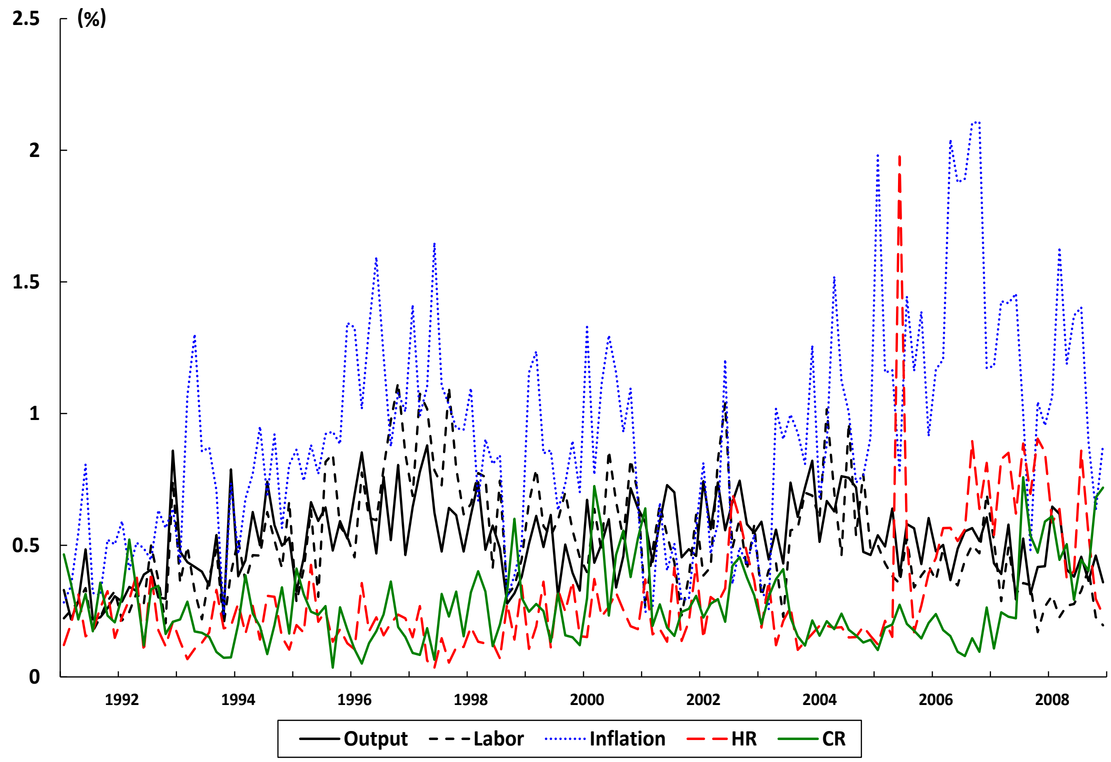
Note: The solid black line in each panel depicts the impulse response function of the specified variable (Federal funds rate, real industrial production, the unemployment rate, and headline CPI) to 100 basis point changes in standard deviation of monetary policy shock for 1969 - 1990. The blue dotted line in each panel shows the response function of the specified variable to 100 basis point changes in standard deviation of monetary policy shock for 1991 - 2008. Shaded bands and blue dashed lines denote the associated 90% confidence intervals for the system.

Figure A.2: Coibion (2012): Hybrid-SVARs with R&R monetary shock



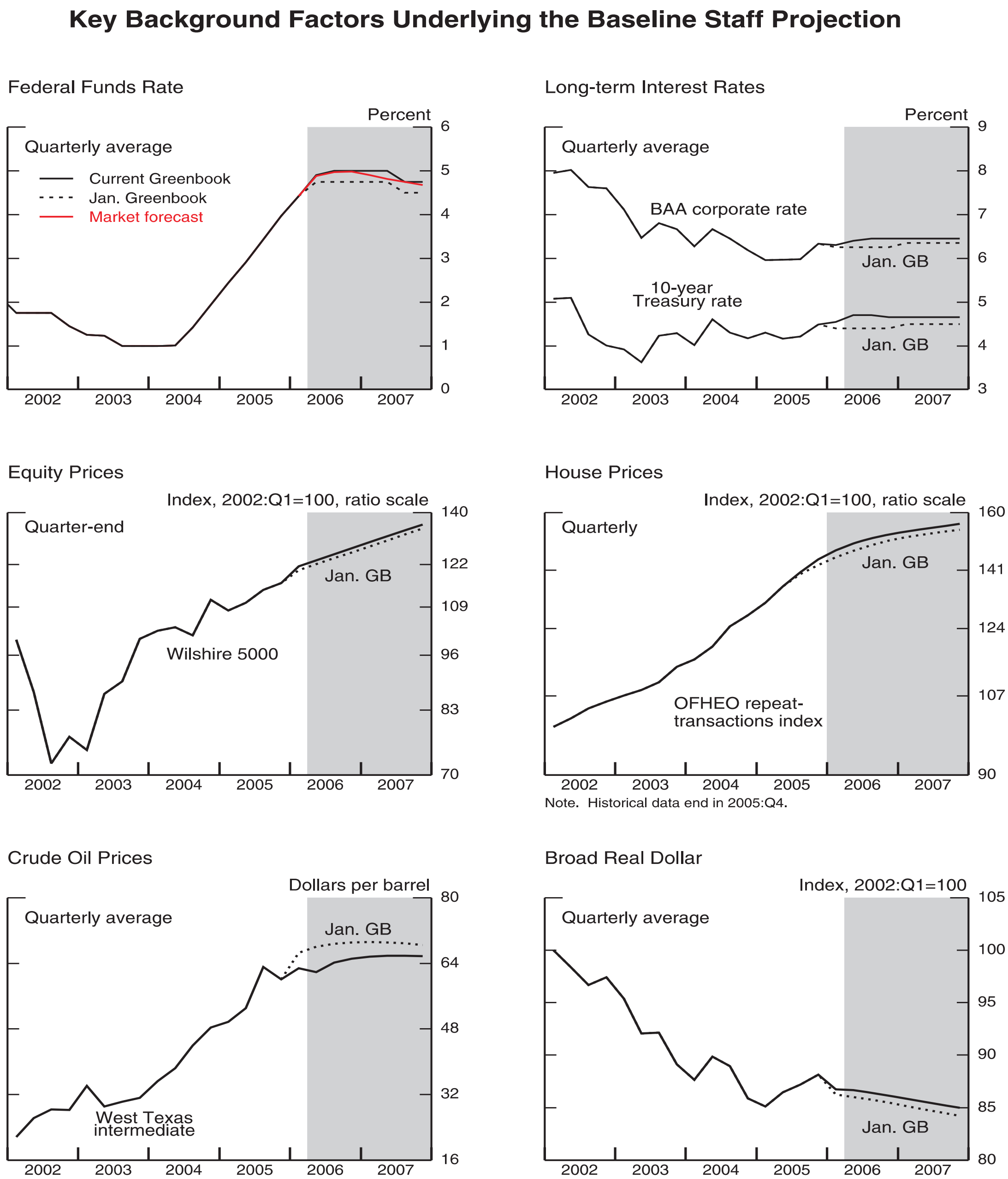
Note: The solid black line in each panel depicts the impulse response function of the specified variable (Federal funds rate, real industrial production, the unemployment rate, and headline CPI) to 100 basis point changes in standard deviation of monetary policy shock for 1969 - 1990. The blue dotted line in each panel shows the response function of the specified variable to 100 basis point changes in standard deviation of monetary policy shock for 1991 - 2008. Shaded bands and blue dashed lines denote the associated 90% confidence intervals for the system.

Figure A.3: Frequency of word count for each group, FOMC transcripts, 1991 - 2008



Note: Each line shows the series of frequency (%) for each group to the total number of words expressed at each FOMC meeting over the period February 1991 through December 2008; Black-Solid line represents the group "Output"; Black-Dashed line represents the group "Labor"; Blue-Dotted line shows the group "Inflation"; Red-Dashed and Green-Solid line illustrate the frequency of terms that are related to housing and credits, respectively.

Figure A.4: Greenbook forecasts for key background factors, March 2006



Note. Shading represents the projection period.

Table A.1: Frequency of terms expressed by the group across the sample

Group	Full sample: 91-08		Pre-period: 91-99		Post-period: 00-08	
	/ total	/ all groups	/ total	/ all groups	/ total	/ all groups
Output	0.52	20.18	0.5	20.51	0.54	19.85
	[0.15]	[5.226]	[0.17]	[4.397]	[0.125]	[5.954]
Labor	0.51	19.45	0.54	21.48	0.48	17.43
	[0.218]	[6.612]	[0.238]	[5.711]	[0.193]	[6.866]
Inflation	0.91	33.52	0.81	33.09	1	33.95
	[0.407]	[10.036]	[0.317]	[8.054]	[0.463]	[11.73]
Housing	0.3	11.23	0.2	8.85	0.4	13.61
	[0.245]	[7.001]	[0.092]	[4.676]	[0.301]	[8.083]
Credits	0.39	15.62	0.36	16.08	0.42	15.16
	[0.194]	[8.329]	[0.165]	[8.53]	[0.217]	[8.158]
All groups	2.63		2.4		2.85	
	[0.612]		[0.581]		[0.561]	
Total terms	19431	521	15549	373	23314	670
Observations	144		72		72	

B High-Frequency Instruments and the role of house prices

The empirical literature on monetary policy has also relied the incorporation on external high-frequency instruments, which are likely to provide direct measures of the structural policy disturbances. For example, Gürkaynak, Sack, and Swanson's (2005) market surprises have been used in Gertler and Karadi (2015), Miranda-Agrippino and Ricco (2021), and Bauer and Swanson (2022) as measures of monetary policy shocks. The use of monetary policy surprises is particularly appealing in these applications because they focus on market interest rate changes within a narrow window of time around FOMC announcements. This approach plausibly rules out reverse causality and other endogeneity problems. For instance, FOMC decisions are made an hour or two before the announcement, indicating that the FOMC could not have been reacting to changes in financial markets in a sufficiently narrow window of time around the announcement. Therefore, the asset price changes are clearly caused by the announcements themselves, rather than vice versa. Additionally, surprises are also typically considered unpredictable with any publicly available information that predates the FOMC announcement. This view is supported by the standard argument that financial market participants would be able to trade profitably on that predictability and drive it away in the process. Hence, monetary policy surprises are plausibly exogenous with respect to all macroeconomic variables that are publicly known before the FOMC announcement itself and this is where the tight window comes in places. The characteristic makes them a valid instrument for the effects of monetary policy in structural VARs and local projections, as discussed in Stock and Watson (2018).

However, a few recent studies have questioned whether monetary policy surprises possess the desirable properties that the literature has typically assumed. For instance, Miranda-Agrippino and Ricco (2021) described that the Fed's internal Greenbook forecasts contain substantial information that is correlated with the high-frequency monetary policy surprise around the subsequent FOMC announcement. Cieslak (2018) and Bauer and Swanson (2022) have documented substantial predictability of monetary policy surprises with publicly available macroeconomic or financial market information that predates the FOMC announcement. These empirical evidence highlight the exogeneity issue, which can be addressed by removing the component of the monetary policy surprises that is possibly predictable, as recommended by Miranda-Agrippino and Ricco (2021) and Bauer and Swanson (2022).

In this paper, the main argument provides empirical evidence that monetary policy decisions systematically respond to changes in house prices by revisiting the narrative approach proposed by Romer and Romer (2004). To this end, Appendix B tests whether house prices can be used as a predictable component in policy surprises, which are measured by a high-frequency instrument. Specifically, Table B.1 examines the correlation with house prices as a proxy for the Fed's internal forecasts for the leading indicators of monetary policy shocks. Meanwhile, Table B.2 focuses on the role of house prices as a publicly available measurement of macroeconomic (or financial) variables that possibly predict upcoming monetary policy surprises.

Table B.1 displays the estimated coefficients and relative significance level of the projection of high-frequency market surprises in the fourth federal funds futures (FF4), the three month ahead monthly fed funds futures as proposed by Gertler and Karadi (2015), over the 3-month moving average of house price growth prior to the FOMC meeting, Greenbook forecasts, and revisions to forecasts for output, inflation, and unemployment. In particular, I employ the movements in the fourth federal funds futures contracts that are registered within a 30-minute window around the time of the FOMC announcements, as suggested by Gürkaynak et al. (2005). The regressions were conducted on all surprises registered between 1990 and 2008 at the frequency of FOMC announcement dates. The first column corresponds to a regression similar to those in Romer and Romer (2004) and reports results analogous to those in Miranda-Agrippino and Ricco (2021), using Greenbook forecasts for output and inflation relative to the previous quarter and up to three quarters ahead, nowcasts for the unemployment rate, and forecast revisions for output, inflation, and unemployment relative to the previous quarter and up to two quarters ahead. The results indicate that high-frequency surprises are correlated with the central bank's private forecasts, although the interpretation of individual coefficients is limited due to the multicollinearity of forecasts for the same variable at different horizons. Overall, the results imply that the Fed's private information is primarily related to the bank's assessment of the short-term macroeconomic outlook. In column 2, I repeat the same analysis by adding house prices to evaluate the role of house prices as a predictive component of monetary policy. The estimated results suggest that house prices have an insignificant coefficient at any significance level, indicating that high-frequency surprises in the fourth federal funds futures possibly capture the effects of demand shocks of house prices through the financial market.

A potentially important concern is related to the role of unscheduled meetings, during which the FOMC makes urgent discussions in times of particular economic distress. These unexpected meetings, which gather market attention, may actually be responsible for the information channel. In my sample period, unscheduled meetings occurred 26 times, most frequently during the Great Recession. Columns 3 and 4 address this concern by repeating the regression in columns 1 and 2, respectively, using market surprises registered around scheduled FOMC meetings only, and the results are found to be robust.

Table B.2 estimate regressions of the form:

$$mps_t = \alpha + \beta X_{t-} + \varepsilon_t \tag{14}$$

where t indexes FOMC announcements for the sample period from 1988 to 2019 and mps_t denotes a measure of the monetary policy surprise as proposed by Bauer and Swanson (2022).[24] The

[24] To construct high-frequency monetary policy surprises, various methods are used by different authors. For instance, Kuttner (2001) uses the change in the current-month federal funds futures contract, Gertler and Karadi

vector X_{t-} consists of seven predictors of macroeconomic and financial data known prior to the announcement t (which are known prior to the announcement, indicated by the time subscript $t-$), including the surprise component of the most recent nonfarm payrolls release, employment growth over the last year, the logarithmic change in the S&P500 from three months before to the day before the FOMC announcement, the change in the yield curve slope over the same period, the logarithmic change in a commodity price index over the same period, the option-implied skewness of the 10-year Treasury yield from Bauer and Chernov (2021), and the three-month moving average of house price growth from two months before the FOMC announcement. The regression residual is denoted by ε_t.

The results from six different versions of the regression (14) are reported in Table B.2. The first and second columns consider the baseline measure of the monetary policy surprise described in Bauer and Swanson (2022) over the full sample of 322 FOMC announcements from 1988 to 2019. The results are consistent with their findings, where strong nonfarm payroll employment, a strong stock market, and high commodity prices predict a hawkish monetary policy surprise, while house prices do not have a significant role in this context. The other four columns of Table B.2 report results for alternative estimation samples. The third and fourth columns repeat regression (14) with the same specification but start the sample in 1994 when the FOMC began explicitly announcing its monetary policy decisions. The results over this sample are very similar to the first and second columns. The last two columns report results for a sample period that stops in June 2007, before the financial crisis and zero lower bound period, again with similar estimates.

Overall, the results in Tables B.1 and B.2 confirm the substantial predictability of high-frequency monetary policy surprises found by previous authors for different samples. Table B.1 implies that there is strong evidence that the Fed's internal forecasts are correlated with the subsequent monetary policy surprises, while Table B.2 shows monetary policy surprises measured by high-frequency instruments are systematically correlated with macroeconomic and financial data that are publicly available before the monetary policy announcement. However, the results associated with house prices in each table show that the predictive power of house prices for policy surprises is marginal. A possible explanation for the predictability results associated with house prices is that a good predictor should have a parsimonious and robust relationship to the Fed's monetary policy rule and a variable of the most recent release measured on an intra-daily basis prior to the FOMC announcement. For this analysis, I used a three-month moving average of house price growth two months prior to the FOMC announcement as a proxy for predictor variables, which is publicly available from the FHFA data archive. Since the predictor's timing was constructed on a monthly basis instead of a daily basis, the predictive power of house prices employed in this analysis for high-frequency monetary policy surprises may not be strong enough to result in a statistically significant estimate. I will leave further exploration of these findings to future studies.

(2015) use the change in a farther-ahead federal funds futures contract, and Gürkaynak et al. (2005) and Nakamura and Steinsson (2018) use a range of federal funds and Eurodollar futures contracts. In this section, I adopt the approach of Bauer and Swanson (2022) and use the first four quarterly Eurodollar futures contracts, ED1-ED4.

Table B.1: Projection of high-frequency market-based surprises

	[1]	[2]	[3]	[4]
House Prices		-0.019		-0.003
		[0.019]		[0.019]
Forecasts				
Output				
h = -1	0.003	0.000	-0.004	-0.004
	[0.004]	[0.004]	[0.003]	[0.004]
h = 0	0.008	0.011	0.009*	0.009*
	[0.006]	[0.007]	[0.005]	[0.005]
h = 1	0.001	0.004	0.002	0.001
	[0.008]	[0.009]	[0.006]	[0.007]
h = 2	-0.002	-0.002	0.002	0.002
	[0.008]	[0.009]	[0.005]	[0.006]
Inflation				
h = -1	-0.013*	-0.014*	-0.011*	-0.012*
	[0.007]	[0.008]	[0.006]	[0.007]
h = 0	0.013*	0.017*	0.011	0.013*
	[0.008]	[0.009]	[0.007]	[0.007]
h = 1	-0.036**	-0.037**	-0.013	-0.017
	[0.015]	[0.017]	[0.013]	[0.015]
h = 2	0.030**	0.026	0.013	0.015
	[0.014]	[0.018]	[0.012]	[0.016]
Unemployment				
h = 0	0.001	0.001	-0.005	-0.005
	[0.006]	[0.006]	[0.005]	[0.005]
Forecasts Revisions				
Output				
h = -1	-0.011*	-0.010*	-0.007	-0.008
	[0.006]	[0.006]	[0.005]	[0.005]
h = 0	0.000	0.002	0.000	0.001
	[0.008]	[0.008]	[0.006]	[0.007]
h = 1	0.004	0.000	0.009	0.008
	[0.011]	[0.012]	[0.010]	[0.010]
h = 2	0.001	0.006	-0.008	-0.001
	[0.010]	[0.011]	[0.009]	[0.010]
Inflation				
h = -1	-0.002	-0.001	0.001	0.005
	[0.010]	[0.009]	[0.010]	[0.009]
h = 0	-0.005	-0.004	-0.003	-0.002
	[0.010]	[0.010]	[0.009]	[0.010]
h = 1	0.040*	0.037	0.023	0.022
	[0.020]	[0.022]	[0.022]	[0.024]
h = 2	-0.025	-0.013	-0.001	0.002
	[0.025]	[0.026]	[0.023]	[0.026]
Constant	-0.031	-0.027	0.001	0.006
	[0.048]	[0.051]	[0.040]	[0.045]
Observations	178	160	152	141
Adjusted R-squared	0.080	0.064	0.114	0.095

Note: Projection of high-frequency market-based surprises on Greenbook forecasts and real house prices. Dependent variable is the 30-minute adjustment in the price of the fourth federal funds future around the FOMC announcements in the sample 1990:2008. The first two columns use all announcement dates, last two the dates of scheduled FOMC meetings only. Robust standard errors are in brackets. *, **, and *** indicate rejection at $\alpha(0.1, 0.05, 0.01)$ significance level, respectively.

Table B.2: Predictive Regressions Using Macro and Financial Date

	[1]	[2]	[3]	[4]	[5]	[6]
Nonfarm payrolls	0.09**	0.11**	0.11*	0.11*	0.08*	0.11*
	[0.04]	[0.05]	[0.06]	[0.06]	[0.05]	[0.06]
Empl. growth (12m)	0.01**	0.01	0.00	0.00	0.01	0.00
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.01]
Δ log S&P 500 (3m)	0.08	0.14*	0.11	0.12	0.15*	0.23**
	[0.06]	[0.08]	[0.07]	[0.07]	[0.08]	[0.10]
Δ Slope (3m)	-0.01	-0.01	-0.01	-0.011	-0.01	-0.01
	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
Δ log Comm. price (3m)	0.12**	0.09	0.09	0.09	0.22***	0.20**
	[0.05]	[0.06]	[0.07]	[0.06]	[0.07]	[0.10]
Treasury skewness	0.03***	0.04***	0.04***	0.04***	0.05**	0.06
	[0.01]	[0.01]	[0.01]	[0.01]	[0.02]	[0.04]
Moving avg (3m). House prices		-0.01		-0.01		0.01
		[0.01]		[0.01]		[0.02]
Observations	322	249	218	218	216	143
Sample	1988:1-2019:12	1988:1-2019:12	1994:1-2019:12	1994:1-2019:12	1988:1-2007:6	1988:1-2007:6
Adjusted R-squared	0.15	0.14	0.15	0.15	0.17	0.17

Note: Columns [1] and [2] show coefficient estimates β from the regression (14) in the sample 1988:2019. Columns [3] and [4] repeat the regression but begins the sample in 1994, while columns [5] and [6] report results for a sample period that stops in June 2007. Robust standard errors are in brackets. *, **, and *** indicate rejection at $\alpha(0.1, 0.05, 0.01)$ significance level, respectively. See text for details.