

**Finance and Economics Discussion Series
Divisions of Research & Statistics and Monetary Affairs
Federal Reserve Board, Washington, D.C.**

**How Effective is Monetary Policy at the Zero Lower Bound?
Identification Through Industry Heterogeneity**

Arsenios Skaperdas

2017-073

Please cite this paper as:

Skaperdas, Arsenios (2017). “How Effective is Monetary Policy at the Zero Lower Bound? Identification Through Industry Heterogeneity,” Finance and Economics Discussion Series 2017-073. Washington: Board of Governors of the Federal Reserve System, <https://doi.org/10.17016/FEDS.2017.073>.

NOTE: Staff working papers in the Finance and Economics Discussion Series (FEDS) are preliminary materials circulated to stimulate discussion and critical comment. The analysis and conclusions set forth are those of the authors and do not indicate concurrence by other members of the research staff or the Board of Governors. References in publications to the Finance and Economics Discussion Series (other than acknowledgement) should be cleared with the author(s) to protect the tentative character of these papers.

How Effective is Monetary Policy at the Zero Lower Bound? Identification Through Industry Heterogeneity

Arsenios Skaperdas^{†‡}

July 3, 2017

First Draft: December 11, 2014

Abstract

US monetary policy was constrained from 2008 to 2015 by the zero lower bound, during which the Federal Reserve would likely have lowered the federal funds rate further if it were able to. This paper uses industry-level data to examine how growth was affected. Despite the zero bound constraint, industries historically more sensitive to interest rates, such as construction, performed relatively well in comparison to industries not typically affected by monetary policy. Further evidence suggests that unconventional policy lowered the effective stance of policy below zero.

JEL Classification: E32, E43, E47, E52

[†]Board of Governors of the Federal Reserve System. Email: arsenios.skaperdas@frb.gov.

[‡]I am thankful for the guidance of my dissertation advisors, Michael Hutchison and Carl Walsh, and the members of my committee, David Draper and Ken Kletzer. I am also grateful to Johanna Francis for continued feedback and encouragement at an early stage. Michael Bergman, Valentina Colombo, Carlos Dobkin, Peter Dunne, Gabriel Fagan, Benjamin Garcia, Stefan Gerlach, Matija Lorenz, Jeffrey Huther, Fergal McCann, Laura Moretti, Gerard O'Reilly, Jonathan Robinson, Ajay Shenoy, Evan Smith, Eric T. Swanson, UCSC Macro, Central Bank of Ireland, Workshop on Empirical Monetary Economics, and Fed Board seminar participants provided helpful comments. Finally, I thank the Monetary Policy Division at the Central Bank of Ireland for an excellent environment to work on revising the paper during April to September 2015. The views expressed in this paper are solely my own and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of anyone else associated with the Federal Reserve System.

1 Introduction

The federal funds rate reached essentially zero in December 2008, at which point the Federal Reserve could no longer provide further monetary accommodation through its traditional policy instrument. Following that time, the unemployment rate continued to rise, while inflation fell below target. The Federal Reserve would thus likely have lowered the federal funds rate further if it were able to.

In order to continue influencing economic activity, the Federal Reserve turned to non-traditional policies. Among these, Large-Scale Asset Purchase programs (LSAPs) involved the purchases of assets while those purchases could no longer affect short-term interest rates. Instead, these programs were meant to lower longer-term interest rates, and influence important yields affecting corporate bond and household mortgage rates. However, these programs were motivated by theoretical channels not believed to be particularly strong before the crisis ([Woodford, 2012](#); [Walsh, 2014](#)).

This paper examines growth during this unforeseen period of low interest rates and unconventional monetary policy. Given the scale of the Great Recession, estimates of previous behavior of the Federal Reserve indicate that the federal funds rate would likely have been decreased to -5 percent ([Rudebusch, 2009](#)). This suggests that a large amount of monetary accommodation- which had been provided in previous recoveries- did not occur, unless unconventional policy had significant effects. Accordingly, one would expect the recovery from the Great Recession to be weaker than previous recoveries. In that case, it would also necessarily be true that industry growth rates would be negatively affected.

The contribution of this paper is thus to ask the following question: did industries typically affected by monetary policy suffer during the recovery from the Great Recession? It is commonly thought that some industries are much more interest rate sensitive than others. Using monetary vector autoregressions, I confirm that industries involved in longer-term projects, or that require large consumer loans, such as construction and durable goods manufacturing, respond more strongly to interest rate shocks ([Dedola and Lippi, 2005](#)). I validate the industry ranking through an alternative measure of monetary shocks from [Romer and Romer \(2004\)](#). If unconventional policy had little effect, we should expect to see that these industries, such as construction, performed poorly in comparison to industries not thought to be typically affected by monetary policy.

In contrast, I find that interest rate sensitive industries performed just as well- if not more so- than in previous US recoveries. As firms also grew about as well on average as in previous recoveries, it must be the case that either unconventional policy had significant

real effects, or that some other shocks on net caused heterogeneous industry effects as an expansionary monetary shock would have. However, I find no evidence for any other such shocks, including plausible alternative explanations such as expansionary fiscal policy or industry-specific productivity growth.

In order to further answer whether unconventional monetary policy had real effects, I present a new time series method for measuring monetary accommodation. Departing from previous literature ([Krippner, 2013](#); [Wu and Xia, 2014](#); [Lombardi and Zhu, 2014](#); [Christensen and Rudebusch, 2013](#)), I develop an approach that infers an implied monetary stance directly from observed industry growth rates and standard variables used in monetary vector autoregressions. I find that that the zero lower bound period is characterized by “below zero” properties, in that observed outcomes occurred as if further federal funds rate decreases had taken place. This provides evidence that unconventional monetary policy was effective, and accounts for the observed positive relative growth rates of interest rate sensitive industries.

Overall, the findings in this paper mirror other results in the literature ([Swanson and Williams, 2014](#); [Gilchrist et al., 2014](#)) which suggest that the Federal Reserve had leeway to influence the economy through unconventional policy. Given the positive relative growth rates of interest rate sensitive industries, and measured accommodative monetary shocks following the incidence of the zero bound, I infer suggestive evidence that the combination of zero interest rates and unconventional policy increased economic activity in a comparable fashion to previous US recoveries for the public firms examined.

The layout of the paper is as follows: Section 2 establishes how this paper relates to the literature on the zero lower bound. Sections 3, 4, and 5 explain the data, methodology, and results of the growth rates of interest rate sensitive industries through time. Section 6 discusses alternative explanations for the findings. Section 7 presents explores whether the results are attributable to unconventional monetary policy. Finally, Section 8 concludes.

2 Related Literature

The identification strategies of this paper rely in part on industry heterogeneity of the effects of monetary policy. A variety of strands of literature have shown heterogeneous effects. [Barth and Ramey \(2002\)](#) find that heterogeneous industry effects can arise from differing degrees of working capital usage through the cost channel, whereby firms’ marginal costs are directly affected by changes in nominal interest rates ([Ravenna and Walsh, 2006](#)). [Gertler and Gilchrist \(1994\)](#) find that small manufacturing firms are more responsive to

monetary policy shocks than large firms, and find evidence that this is at least partly due to the credit channel. [Ehrmann and Fratzscher \(2004\)](#) and [Maio \(2013\)](#) examine heterogeneous stock market movements in response to monetary shocks. Finally, structural VAR evidence for heterogeneous industry effects can be found in [Dedola and Lippi \(2005\)](#) and [Peersman and Smets \(2005\)](#). The approach in this paper builds on that of [Dedola and Lippi \(2005\)](#) in the basic specification of a VAR to identify how sectors respond to interest rate shocks.

This paper’s results are particularly relevant in light of macro research that has implied that the effective short-term interest rate following 2008 was negative. [Krippner \(2013\)](#) and [Wu and Xia \(2014\)](#) use term structure models to calculate “shadow rates” of the stance of monetary policy, by evaluating what nominal interest rate would normally create observed yield curves. These papers attempt to measure the short-term interest rate implied by financial markets. In contrast, Section 7 estimates the effective federal funds rate as implied by real macroeconomic variables and industry growth rates.

Finally, this paper follows [Claessens et al. \(2011\)](#) and in the use of firm-level data to answer macro questions. [Claessens et al. \(2011\)](#) examine the diffusion of the Global Financial Crisis on firms from a large sample of countries using differences-in-differences from the start of the crisis to the trough. In contrast, this paper examines economic recoveries, and uses previous recoveries to benchmark what we should quantitatively expect for firm growth. For the sectoral (industry) interest rate sensitivity index, I draw inspiration from [Rajan and Zingales \(1998\)](#) in capturing time-invariant intrinsic sector characteristics.

The analysis in this paper has begun from the premise that interest rate decreases have non-negligible effects on output. If this is not the case, this paper’s results provide no meaningful evidence that monetary policy is effective at the zero lower bound. However, evidence for nominal rigidities is unambiguous ([Steinsson and Nakamura, 2014](#); [Gorodnichenko and Weber, 2014](#)). I thus proceed under the presumption that these rigidities do result in real effects.

3 Data

3.1 Data Sources

I use Compustat data for access to a firm-level database with relevant firm covariates. This database contains quarterly and yearly information on the universe of publicly listed

companies in the US. As such, all results are local to public firms. In the conclusion, I discuss how representative is this sample of firms as a whole.

For ranking industry interest rate sensitivity, I use the Compustat Quarterly North America database and the 1970:Q1-2008:Q3 time period. This sample is chosen such that it precedes the crisis period and the incidence of the recovery at the zero lower bound. I then use the resulting ranking to predict revenue growth using Compustat annual data. All US macro data is from FRED. Fiscal variables are taken from the Bureau of Economic Analysis.

3.2 Industry Time Series Construction

To my knowledge, no consistent time series of industry growth exists.¹ I thus construct time series using Compustat data.

The timing of firm entry and exit into the Compustat database is an endogenous outcome of many variables. Regulatory changes, investor sentiment, and other factors could make it more appealing for firms to go public or merge during certain time periods. When examining revenues, this would erroneously make it appear during times of increased corporate entry that an industry had grown (in aggregates) or shrunk (in averages, assuming entering firms are small). In fact, mean industry revenues do not follow any clear growth trend. I thus examine growth rates of revenues rather than aggregates or averages.²

I follow the micro employment literature (Davis et al., 1998) in specifying firm-level growth rates as

$$g_{i,j,t-k,t} = \frac{y_{i,t} - y_{i,t-k}}{0.5[y_{i,t} + y_{i,t-k}]} \quad (1)$$

Where $y_{i,t}$ is the variable of interest of firm i , in industry j , in quarter t . This bounds the measure to a $[-2, 2]$ interval and approximates the effect of log differences. This growth rate measure accounts for firm entry and exit symmetrically, corrects for the effects of outliers, and helps control for mergers.

Finally, I use year-over-year growth rates to avoid deseasonalizing. This ignores firms that exist for less than four quarters, provides a less volatile metric of firm growth than quarter over quarter measures, and allows for firms that only report revenues once a year over parts of the sample. The growth rate in quarter t of industry j is thus constructed as the industry average of (1)

¹The Bureau of Economic Analysis does collect industry value added, among other variables, but has no industry data spanning a time period long enough for a VAR analysis due to reclassification.

²I cannot calculate industry value added, as the Compustat database has only sparse data on wages and salaries.

$$g_{j,t} = \frac{1}{n_{j,t}} \sum_{i=1}^{n_{j,t}} g_{t-4,t}^i \quad (2)$$

Where $n_{j,t}$ is the number of firms in industry j at time t with year-over-year revenue statistics.

4 Methodology

This section discusses the methodology of the first approach I use to investigate monetary policy at the zero lower bound. The approach involves two steps: estimating an industry interest rate sensitivity index, then using the index in a second-stage regression which evaluates industry revenue growth at the zero lower bound. This section explains the methodology, while Section 5 presents the results from the two steps.

4.1 Industry Interest Rate Sensitivity Index Construction

The interest rate sensitivity index is created using industry-level impulse responses from structural vector autoregressions. This approach makes a minimum number of assumptions on the data, identifying the effect of interest rate changes that cannot be predicted by contemporaneous and lagged values of other variables in the model.³ I use the SVARs to measure to what extent an unpredictable interest rate increase is associated with future decreases in revenues for each industry. The ranking is highly correlated across SVAR lag lengths, recursive orderings, and a variety of other specification choices, including subsample analysis where the VARs are estimated beginning in the 1980s.⁴

In order to measure the interest rate sensitivity index, I employ the following SVAR model for each two digit NAIC industry:

$$B_0 Y_t = C + B_1 Y_{t-1} + u_t \quad (3)$$

The SVAR is identified recursively, with the exception that industries are small relative to the macroeconomic aggregates, and cannot affect them. I impose constraints on parame-

³An alternative approach to isolate industry level interest rate sensitivity, which requires market efficiency, would be to examine the industry heterogeneity of stock returns due to unanticipated federal funds rate changes. This would require differentiation of stock movements into real interest rate news, dividend news, and future excess return news. Unfortunately, this approach yields statistically imprecise estimates of industry heterogeneity, as found in [Bernanke and Kuttner \(2005\)](#).

⁴These robustness checks are presented in the online appendix.

ters such that industries do not affect any of the macroeconomic variables.⁵ Empirically, quarterly corporate industry revenues are a relatively small portion of gross revenues, justifying this structure.⁶

Structural shocks are recovered through the following contemporaneous restrictions:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{2,1} & 1 & 0 & 0 & 0 \\ a_{3,1} & 0 & 1 & 0 & 0 \\ a_{4,1} & 0 & a_{4,3} & 1 & 0 \\ a_{5,1} & 0 & a_{5,3} & a_{5,4} & 1 \end{bmatrix} \begin{bmatrix} \epsilon_{Output,t} \\ \epsilon_{IndustryRev,t} \\ \epsilon_{Commodities,t} \\ \epsilon_{Inflation,t} \\ \epsilon_{Fedfunds,t} \end{bmatrix} = \begin{bmatrix} u_{Output,t} \\ u_{IndustryRev,t} \\ u_{Commodities,t} \\ u_{Inflation,t} \\ u_{Fedfunds,t} \end{bmatrix}$$

As shown, the Y_t vector is composed of and ordered in the following manner: real GDP growth, industry revenue growth, commodity price inflation,⁷ personal consumption expenditures inflation,⁸ and the federal funds rate.⁹ The C vector contains only constants; no other exogenous terms are needed as all variables other than the federal funds rate are year-over-year growth rates, in order to match with time series of industry revenues. A lag length of 4 is chosen as suggested by the AIC.

Three industries, Agriculture, Forestry, Fishing and Hunting (11), Transportation and Warehousing (49), and Educational Services (61), have significantly fewer quarterly firm observations in the sample.¹⁰ Since these industries each have such a small number of firms, VAR results using these industry aggregates are more uncertain due to the larger effects of idiosyncratic firm-level shocks. The series for these industries are characterized by much higher variability than the other industries, and as Table 1 shows, NAICS (11), (49), and (61) have among the largest standard deviations of industry revenues.

I deal with this problem by dropping these industries from the sample. This results in dropping all industries with fewer than 24 firms per quarter on average, which comprise 0.09% of firm observations used in the second-stage analysis.¹¹

I quantify the SVAR revenue effects of monetary policy by recording the minimum

⁵Thus, the parameters characterizing macroeconomic aggregates are by construction equal to the parameters resulting from a standard recursive VAR. Relaxing VAR specifications to allow industry outcomes to affect macroeconomic aggregates yields very similar industry impulse responses to a monetary shock, as the Federal Reserve is not measured to react to individual industry outcomes.

⁶This figure is shown in the online appendix.

⁷Series PPIACO from FRED.

⁸The is the primary designated inflation rate used by the Federal Reserve, series PCEPI from FRED.

⁹The identification scheme used is standard in the literature for VARs analyzing monetary policy with quarterly data (Christiano et al., 1999).

¹⁰A chart of quarterly firm observations by industry is shown in the online appendix, as is a plot of the constructed industry time series.

¹¹In the online appendix, it is shown that including these industries does not change any of the results.

point estimate¹² of the orthogonalized industry revenue response, over a four year horizon, to a positive one standard deviation interest rate shock from each SVAR in system (3). To ease interpretation of the index in predicting firm recovery, I standardize the orthogonalized impulse responses with respect to each other and multiply by -1 . In second-stage regressions used to investigate the zero lower bound, this makes it such that a positive value on the index, denoted by ϕ_j , is associated with positive growth. Each firm i 's index sensitivity is based on its industry's standardized orthogonalized impulse response. A one unit increase in the index thus signifies a one standard deviation increase in interest rate sensitivity.¹³

Formally, let $\chi_j = \min_{t=0}^{16} \left(\frac{\partial g_{j,t}}{\partial u_{5t}} \right)$, where $g_{j,t}$ is the revenue growth rate at quarterly horizon t for industry j , and u_{5t} is a one standard deviation orthogonalized shock to the federal funds rate. Then each firm in industry j has its interest sensitivity assigned to be

$$\phi_j = -1 \cdot \left(\frac{\chi_j - \bar{\chi}_j}{\sigma} \right) \quad (4)$$

where σ denotes the standard deviation of χ_j .

4.2 Second-Stage Analysis

I first use the industry ranking to trace out the time-varying evolution of the relative growth rates of industries identified as interest rate sensitive. This will reveal that interest rate sensitive industries have not suffered at the zero bound relative to historical norms. I then use the standardized sensitivity index to predict real revenue growth, as defined in equation (1), in the following more rigorous second-stage specification:

$$g_{i,j,t-k,t} = \psi \cdot (\phi_j I_{2009,2012}) + \delta \phi_j + \gamma_{t-k,t} I_{t-k,t} + \beta X_{i,j,t-k,t} \cdot I_{t-k,t} + \epsilon_{i,j,t-k,t} \quad (5)$$

Where $g_{i,j,t-k,t}$ is the revenue growth rate between years $t-k$ and t of firm i , in industry j . $I_{t-k,t}$ is an indicator for each of the three recoveries, while $\gamma_{t-k,t}$ captures each recovery's trend growth. The coefficient ψ on the interaction term $\phi_j I_{2009,2012}$ captures the difference in real revenue growth for firms in sensitive industries relative to insensitive industries,

¹²Industries with positive responses to monetary shocks are thus set to zero before standardization. Alternative specifications of the index are presented in the online appendix and yield similar results.

¹³The literature on monetary policy has noted that the effects of monetary shocks are asymmetric depending on the phase of the business cycle (Weise, 1999; Chen, 2007; Tenreyro and Thwaites, 2013). For example, a contractionary shock during an expansion may have different effects than a contractionary shock during a recession. For the purposes of this paper, I examine the symmetric case, as is the case in the majority of the VAR literature.

at the zero lower bound, in comparison to the previous two recoveries, captured by δ . In baseline specifications, I examine recoveries using the timing of 1991-1994, 2001-2004, and 2009-2012 for the recovery years, as these correspond to periods after which the Fed eased policy following a recession.¹⁴ The vector $X_{i,j,t-k,t}$ consists of a number of control variables, to be explained, allowed to have different effects in each recovery.¹⁵ Equation 5 is thus similar to running three separate OLS regressions over the periods 1991-1994, 2001-2004, and 2009-2012, with the difference being that the correlation between industry revenue growth and industry interest rate sensitivity is constrained to be the same over 1991-1994 and 2001-2004 recoveries (δ), while I measure the difference in this correlation over the 2009-2012 ZLB period (ψ).

In all specifications, ψ captures the difference in revenues growth for firms in highly interest rate sensitive industries relative to firms in low sensitivity industries. If the zero bound has been a severely binding constraint on monetary policy, and hence aggregate growth, it must be the case that industry growth rates have been negatively affected. We should then expect to see that ψ is significantly negative.

Table 11 presents summary statistics on relevant firm variables used in this paper. It is of interest to note that the 2009-2012 recovery is not characterized by lower revenue or employment growth than previous recoveries. In fact, the 2009-2012 period has greater employment and revenue growth than the 2001-2004 recovery.

5 Empirical Results

5.1 SVAR Index Results

I first investigate the industry interest rate sensitivity classification. Figure 1 graphs the orthogonalized industry impulse responses to an interest rate shock upon which the standardized index is created.¹⁶ Table 2 presents the minimum response values to a one

¹⁴The year of each recovery start is set according to NBER dates. These most recent recoveries are examined as they provide a closer comparison to the zero lower bound recovery rather than pre-Great Moderation. Examining other year choices for the recoveries give similar results.

¹⁵Note that the control variables are thus allowed to be time-varying. This is important because, for example, industry GDP elasticity will have different effects depending on the strength of GDP growth, which varies across the three recoveries examined. Likewise, log firm employment at the start of each recovery may have different effects in 1991 than 2009, as firms on average are larger in 2009.

¹⁶In all figures, 90% standard error bands are calculated using a circular (moving block) bootstrap. Steps are as follows: an artificial time series is created, equal in length to the sample, using random samples of block length 4 drawn with replacement from a circle of the SVAR residuals, initiated with 1971:Q1-1971:Q4 values. The SVAR models are estimated over the artificial time series, yielding distribu-

standard deviation shock, along with the standardized reciprocal explained previously. The ordering of industries aligns with common priors. Broadly speaking, industries classified as more interest rate sensitive are capital intensive and produce goods of greater durability, as found in previous literature (Dedola and Lippi, 2005).¹⁷

According to the responses, Construction (23)¹⁸ and Mining, Quarrying, and Oil and Gas Extraction (21)¹⁹ are the most sensitive sectors. These are industries that are highly affected by investment funding levels. The most responsive manufacturing sector, NAIC 33, is composed mostly of durable goods (as in Erceg and Levin (2006)), which are intertemporally substitutable. Overall, the most sensitive sectors consist of firms that either undertake long-term projects sensitive to the cost of capital, or produce goods that require large consumer loans.

Service industries including Health Care and Social Assistance (62), Professional, Scientific, and Technical Services (54), and Other Services (81), are less affected by interest shocks. These industries do not rely on inventory or production chains for revenues, making them less affected by the credit channel. Arts, Entertainment, and Recreation (71), though a service industry, may be more affected by decreases in disposable income.

The finding that the Retail Trade sectors (44 and 45) are not more affected may be surprising. However, it is important to note that uncertainty over the impulses responses implies that many of the industries with intermediate responses to interest rate shocks are not statistically differentiable from each other. In addition, it is possible that exchange rate changes following interest rate changes mitigate the net effect on retail.

That utilities are somewhat affected by interest rates may be counterintuitive. In fact, utility companies have high debt loads,²⁰ and many utility companies are subject to regulation which can cause decreases in their ability to adjust to interest rate changes.

It is important to mention that the ranking of industries by magnitude to an interest rate shock: construction, durable goods, non-durable goods, and the services sector, is mirrored by impulse response results from a VAR using these disaggregated components of

tions of impulse responses. This process is repeated 200 times. The standard error bands are calculated using the 5th and 95th empirical quantiles of the impulse responses at each horizon.

¹⁷These authors also find evidence that sensitive industries have higher degrees of working capital usage and external financial dependence

¹⁸Evidence from the Bureau of Economic Analysis national accounts also shows that residential investment is the most affected of all components of GDP by VAR interest rate shocks; as found by Bernanke and Gertler (1995).

¹⁹The oil and natural gas industries have similar rates of growth to other industries in NAIC 21, such as coal mining, during the zero lower bound period.

²⁰Of all industries, utility companies have the largest firm-year average of long term debt expense as a percent of total assets in sample.

GDP. Thus, the industry impulse responses using Compustat firms are similar to impulse responses of aggregates from the national accounts.

The VAR impulse responses to an interest rate shock are shown in Figure 2. Although prices do rise initially in response to an interest rate shock, this increase is small and statistically insignificant.²¹

5.2 Second-stage

Correlations

It is valuable to present the data in a graphical manner. Figure 3 charts coefficients on interest rate sensitivity from three year industry-level growth rates regressed on year indicators and year indicator-interest rate sensitivity index interactions. This charts the equivalent of the coefficient estimates on interest rate sensitivity (ϕ_j) in an OLS regression over each three year window of revenue growth in the following regression.²²

$$g_{j,t-k,t} = \alpha + \beta\phi_j + \epsilon_{j,t-k,t} \quad (6)$$

The coefficients trace the time-varying association between interest rate sensitivity and relative industry growth rates. As shown, the post-2009 period has a similar trajectory to the 2001 recovery. This is a major finding of this paper. If the zero lower bound has severely constrained monetary policy, we should see that interest rate sensitive industries have been detrimentally affected. This is not the case.

Another interesting aspect of Figure 3 is that the pre-crisis years in the 2000s are characterized by large increases in revenues of interest rate sensitive industries. Ex-post, we now know that this time period was characterized by over-exuberant growth in industries sensitive to loosening credit standards. These are also the industries, such as construction, which would be typically affected by monetary policy.²³ Figure 3 is reassuring in the sense that it confirms the relevance of the interest rate sensitivity index with priors about how industries affected by monetary policy evolved before the crisis, though it does not prove that monetary policy was the cause of the buildup.

We would expect to see growth in interest rate sensitive industries in the post-1991

²¹The fact that prices initially rise as a result of a contractionary shock, the price puzzle, is a common finding in the literature. One theoretical reason proposed is the cost channel of monetary policy (Ravenna and Walsh, 2006). In a meta-analysis, Rusnák et al. (2013) find that the only consistent way to solve the price puzzle is to implement sign restrictions which impose prices to decrease.

²²Two year industry growth rates result in similar dynamics.

²³The finding that interest rate sensitive industries grew abnormally fast in the buildup to the crisis is consistent with a vast literature examining the effects of the housing bubble (Mian and Sufi, 2009).

period. The fact that no such growth occurred is worrying given the substantial easing that occurred during that time. However, the late 80s and early 90s were characterized by a very high number of FDIC insured bank failures, as shown in Figures 4.²⁴ Furthermore, the savings and loans crisis contributed to a larger number of failures of financial intermediaries. If one takes the findings of this paper at face value, the Federal Reserve’s proactive actions in stabilizing the financial sector following the 2008 crisis were more effective at increasing the growth of interest rate sensitive industries than the easing that occurred in the 1990s. However, it is likely that other factors were also at play than monetary policy, which is not normally the predominant factor in business cycles, especially outside of the zero bound. Thus, it may be the case that the post-2001 recovery provides a better counterfactual for the zero lower bound period, with which the post-2009 period still compares favorably. Regardless, the important aspect of Figure 3 is that the post-crisis recovery, relative to historical norms, does not seem to be characterized by the monetary contraction implied by a severe liquidity trap.²⁵

As a second exercise, I chart scatter plots of industry revenue growth rates and interest rate sensitivity in Figure 5. As mirrored in the preceding figure, the 1991-1994 recovery is characterized by relatively little growth in interest rate sensitive industries. The post-2001 recovery is characterized by 5% growth for each standard deviation increase in index sensitivity. Finally, the 2009 recovery is characterized by similar industry growth patterns to the post-2001 period. If the zero lower bound period resulted in roughly a 5% contractionary monetary shock, as implied by Taylor rule type reaction functions (Rudebusch, 2009), we would not expect industry revenue differentials due to interest rate sensitivity to be positive. There is no evidence here that interest rate sensitive industries have been detrimentally affected by monetary policy during the zero lower bound period.

Econometric Analysis

Table 3 presents the basic test of this paper, estimating equation (5) at the firm-level. Firm-level data is useful, as it will allow firm-level controls. The coefficient on the index interacted with 2009-2012 reveals that a one standard deviation increase in industry sensitivity is associated with positive increases in relative revenues over that period in comparison to previous recoveries, though this is statistically insignificant.²⁶

²⁴Of course, the Treasury and Federal Reserve also took actions that resulted in large bailouts following the 2008 financial crisis, while the FDIC was not as involved.

²⁵Although Figure 3 appears to have a trend, this must be incidental, as it would imply that interest rate sensitive industries increasingly become a larger portion of the economy.

²⁶The index coefficient itself equals zero, as it is a combination of the 2001-2004 recovery, which is characterized by negative growth, and 1991-1994, which is characterized by positive growth.

The fact that the interaction of the index and the 2009-2012 indicator is no less than previous recoveries is a major finding of this paper. Firms in industries typically sensitive to monetary policy have not had diminished revenue growth in the current recovery, providing evidence that these industries have not been affected by the zero lower bound. Note that if spreads have moved differently relative to the federal funds rate since 2009, and transmission from the federal funds rate to other interest rates has been weaker, this should also result in a decreased coefficient for 2009-2012. We do not observe that this is the case.

In order to rule out other factors that could bias the coefficients, I include control variables in columns (2) through (4). The control variables do not diminish the magnitude of the coefficient ψ at the zero lower bound, meaning that the index is capturing variation separate from traditional characteristics of firms affected by monetary policy. To show that the results are not driven by business cycle variations, I include a sector level measure of GDP growth elasticity. Specifically, I regress revenue growth on annual GDP growth for each sector using yearly data from 1985 to 2012. I then save each elasticity, and interact it with GDP growth from each recovery in second-stage specification (3). All results are unchanged when controlling for sector-specific business cycle elasticities. This is reassuring, as it signifies that the VAR approach is capturing a shock which is orthogonal to industry-level GDP dependencies.

I include lagged log firm employment in the regression in column (3). Firm employment at the start of each recovery could be correlated with firm revenue growth due to financing friction differences between small and large firms, as documented by [Gertler and Gilchrist \(1994\)](#) in the manufacturing industry. In addition, important differences in employment growth dynamics have been found across small and large firms, depending on the aggregate unemployment rate ([Moscarini and Postel-Vinay, 2012](#)). The use of firm-level data provides the benefit of being able to adequately control for these factors. Reassuringly, the inclusion of firm employment does not change the relationship between the index and firm revenue growth.

One possible confounder is that industry trends could be correlated with the interest rate sensitivity index, thus biasing the results. If firms ranked as sensitive have secular growth over the sample period, becoming a relatively larger share of output, this would erroneously make it appear that sensitive firms grew more over the recovery periods due to monetary policy. In order to test for this, I take quarterly firm averages of revenues of each NAIC sector from 1984-2008. I then calculate trend growth of revenues by regressing revenues on a time trend. I use the predicted trend coefficient as a measure of secular

industry growth in the second-stage regressions. In all cases, this secular growth measure does not affect the results in any way, implying that secular trends are not driving the index coefficient estimates.²⁷

Although column (4) of Table 3 controls for secular industry trends over the sample period, it is still possible that shorter growth trends could exist in industries sensitive to monetary policy. If interest rate sensitive industries had relatively faster growth before the recoveries, and this differential continued, it would erroneously make it appear that monetary policy was causing the recovery. Table 4 estimates equation (5), using the time periods preceding the recoveries (1988-1991, 1998-2001, and 2006-2009). The index coefficients are negative, meaning that there were industry pre-trends correlated with interest rate sensitivity. However, the 2006-2009 coefficient estimate is not statistically significant.

It is worrying that the index coefficients are significantly negative in Table 4, as it means that firms in interest rate sensitive industries suffered greater decreases in revenues during those recessions. It is often thought that recessions are followed by above-average growth, returning economies to pre-recession trajectories of potential output. This would likely be mirrored by above-average growth in industries that were hit hardest in the recession. If this is the case, we would expect the index coefficient to be of a stronger magnitude than in previous recoveries.²⁸

In order to control for this potential mean reversion, I use three year lagged growth rates as control variables.²⁹ Table 5 presents the results, showing that the index coefficients from 2009-2012 are unchanged from Table 3, meaning that mean reversion cannot account for the growth in industries sensitive to monetary policy.³⁰

The index ϕ is itself actually a generated variable, $\hat{\phi}$, whose uncertainty has not been

²⁷This control variable is not interacted with the recovery indicators $I_{t-k,t}$, constraining it to have the same value across recoveries. I do this since the purpose of the control variable is to show that growth rates during the recoveries are not driven by a single factor common across the time sample.

²⁸Martin et al. (2014) examine HP filtered output before and after 149 recessions in advanced economies from 1970, and find that, in fact, recessions are not followed by above average growth. Recessions are followed by decreased revisions of potential output. The authors state that it is likely researchers using two-ended data find that the economy returns to potential, but with one-sided data, the true trend is not apparent.

²⁹Specifically, I include the growth rates from 1988-1991, 1998-2001, and 2006-2009 interacted with the recovery indicators in equation (5).

³⁰Using the growth rates from 1988-1990, 1998-2000, and 2006-2008 as controls interacted with the recovery indicators yields the same results. Note that these estimates could be biased due to the correlation of firm fixed effects with the error term, though using previous years means that the firm fixed effect is not mechanically correlated. Using lagged dependent variables as instruments is difficult in this context given the small number of industry observations. In addition, controlling for firm employment helps to control for differential growth trends related to firm size.

taken into account thus far. Table 6 bootstraps over all possible indices to adjust for this.³¹ The standard errors correcting for generated regressors are comparable to the industry-clustered standard errors, though slightly larger on the index interactions. The bootstrapped corrected standard errors do not meaningfully change the value of inference from the results.

5.3 Romer and Romer’s Alternative Shock Measure

In this section, I provide external validation of the industry ordering using Romer and Romer (2004)’s alternative method to identify monetary shocks.³² The authors use internal Fed forecasts to construct a series of intended federal funds rate changes that are purged of information of future output and inflation. This leaves variation that should be orthogonal to developments of these variables, allowing the series to be used as an explanatory variable while being relatively free of endogeneity.

Following Coibion (2012), I cumulate R&R’s shock measures and use it in hybrid VARs, analogous to (3), with the cumulative new shock measure in place of the federal funds rate.³³ I construct the index using the SVAR impulse responses in the same fashion as explained in Section 4.1. The resulting industry ordering using R&R has a correlation of 0.85 with the baseline SVAR index (Table 7). Thus, using the federal funds rate or the R&R shock measure results in a very similar industry ordering. Likewise, controlling for fiscal variables, and using non-financial output in the VARs with the R&R shocks results in a highly correlated measure.³⁴ Table 8 reveals that second-stage estimates using the R&R shock series result in zero lower bound estimates that are quite similar to the results using the federal funds rate, though the third column does have increased standard errors.

³¹Pagan (1984) has shown that equation (5) will yield inconsistent standard errors if uncertainty from index construction is not taken into account. I employ a bootstrapping technique to show that correcting for generated regressors does not change the statistical significance of coefficients. For each sequence of impulse responses, 200 possible indices are created from each iteration of industry SVARs described in Footnote 16. An index is drawn with replacement from this distribution, then 19 industry clusters are drawn with replacement for the second-stage, and Equation (5) is run. The standard deviations of the point estimates are then the bootstrapped standard errors of the coefficients. Industry-level data is used for this calculation so as to decrease computational burden.

³²The shock series, updated and used from 1971:Q1-2007:Q4, can be obtained from Silvia Tenreiro’s website.

³³The hybrid VAR methodology involves summing up the series of shocks up to time t for each t in the sample. This creates a level series comparable to the federal funds rate for the VARs, except that it contains only exogenous movements of the interest rate as identified by R&R. I use hybrid VARs since this helps to control for many factors that can cause omitted variables relative to a univariate regression with volatile industry data.

³⁴The specification of the SVARs for this index is expanded upon in Section 7.

6 Possible Alternative Explanations

6.1 Productivity Increases

In a recovery generated by monetary policy, we would expect revenues in industries positively affected by monetary policy to have proportional increases in hours. That is, we would expect sectors to have movements along their production functions, rather than shifts in their production functions due to technological advances.

Recent literature ([Fernald, 2014](#)) has found diminished productivity growth leading up to and through the Great Recession. Nonetheless, a formal test of productivity growth against the monetary industry index is necessary.

Table 9 estimates equation (5) with real revenues over employment growth, for a measure of labor productivity, as the independent variable.³⁵ In none of the the recoveries is the index significant, meaning that firm labor productivity growth cannot account for the growth of interest rate sensitive industries, including at the zero bound.

I additionally test for the interaction between multi-factor productivity growth and the sensitivity index by using data from [Rosenthal et al. \(2014\)](#). The authors combine industry-level output and intermediate inputs from the Bureau of Economic analysis with capital and labor statistics from the BLS Productivity Program to calculate contributions to aggregate growth in value-added by industry. The data is aggregated slightly differently than NAICs code. Specifically, the authors have a durable and non-durable categorization. I thus assign durable goods to be NAIC 33, and 31 and 32 to be non-durables, as the 3-digit NAIC categorizations fall mostly along this line.³⁶

Figure 6 presents scatter plots and an OLS regression of the sensitivity index and multi-factor productivity growth from 2009-2012³⁷ by 2-digit NAIC industry. As shown in the figure, there is little relationship. Thus, productivity increases cannot account for the positive coefficient on the index sensitivity index, and are not biasing the results.³⁸

³⁵Bureau of Labor Statistics data reveals that correlations between employment and hours worked in 1991,1994, 2009, and 2012 are all greater than 0.98. The correlations in 2001 and 2004 are 0.895 and 0.921 respectively. Hence, the BLS data suggests that using employment as a proxy for hours from 2009-2012 is acceptable.

³⁶The mapping from [Rosenthal et al. \(2014\)](#)'s study to NAIC 31, 32, and 33, does not affect the results. For retail trade, I assign both NAIC groups (44 and 45) to the same value that the authors provide.

³⁷These are the only years for which multi-factor productivity growth data is available, so I cannot test the relationship for 1991-1994 and 2001-2004.

³⁸Including multi-factor productivity growth in Equation 1 leaves coefficient estimates in the regression unchanged.

6.2 Fiscal Policy

One observationally equivalent explanation for the positive coefficient on interest rate sensitivity from 2009-2012 is that fiscal policy was able to counteract the effects of a contractionary monetary shock. Faced with the greatest financial crisis since the Great Depression, Congress passed the American Recovery and Reinvestment Act of 2009 (ARRA) in February of that year. The economic stimulus package resulted in an estimated \$831 billion increase in spending between 2009 and 2019, including increases in unemployment benefits, and direct spending on infrastructure.

The literature has found that the net effect of ARRA was relatively small. In comparison to a panel of countries, [Aizenman and Pasricha \(2013\)](#) find that the US was ranked in the bottom third in growth of public spending. Likewise, [Aizenman and Pasricha \(2010\)](#) find that after factoring in decreases in state and local government spending, consolidated government spending was insufficient to counteract decreases in private demand. These evaluations of ARRA are corroborated by [Cogan et al. \(2010\)](#). The authors estimate the output effects of government purchases using the Smets-Wouters model, and find maximum effects of 0.3% of GDP in 2009:Q3. Following the end of the Great Recession, fiscal policy was unprecedentedly contractionary ([Cashin et al., 2016](#)).³⁹

I thus control for fiscal policy by constructing an industry-level measure of the effects of government spending in a similar to manner to the approach for measuring interest rate sensitivity. I run VARs for each industry while adding the growth rates of government spending⁴⁰ and tax receipts as the first and second ordered variables in the VAR. The VAR specification is described at greater length in Section 7. I quantify the resulting industry responses to government spending by summing the cumulative response over a 16 quarter horizon to an orthogonalized government spending shock.⁴¹ The cumulative industry responses are then standardized with respect to each other.

The resulting measure of industry sensitivity to fiscal policy is negatively correlated with the baseline interest rate sensitivity index ($\rho = -0.37$).⁴² This negative correlation is intuitive, as interest rate sensitive industries would also be sensitive to increases in interest rates due to crowding out, as long as they are not disproportionately awarded government funds. Mining, Quarrying, and Natural Gas, for example, was found to be

³⁹Quarterly year-over-year growth rates of government consumption and investment spending were negative from mid-2010 to mid-2014.

⁴⁰The series used is government consumption and gross investment from the National Accounts.

⁴¹Note that since government spending shocks can have both positive and negative industry revenue effects due to crowding out, the cumulative sum of the revenue impulse response is a more adequate measure than the minimum used for constructing industry interest rate sensitivity

⁴²The resulting fiscal policy sensitivity index is presented in the online appendix.

highly sensitive to interest rates. Similarly, a positive government spending shock results in a decrease in revenue for this industry.⁴³

Including industries' sensitivity to fiscal policy to the baseline regressions of this paper does not change the finding that the zero bound recovery is no different than previous recoveries. Column (2) of Table 10 controls for industry sensitivity to fiscal policy. The second-stage estimates of industry interest rate sensitivity during the zero bound, though diminished, are not significantly different from other recoveries. Column (3), which includes controls, yields similar results. Interestingly, the coefficient on fiscal policy sensitivity interacted with the zero bound period shows that those industries fared significantly worse in revenue growth than during other times. This is consistent with unprecedented fiscal contraction during the zero bound decreasing growth.

7 Identifying the Policy Stance

7.1 Methodology

Thus far, evidence on monetary policy effectiveness has been presented through an inferential approach comparing recoveries. In this section, I evaluate how much the results are attributable to unconventional policy, and provide time series rather than cross-sectional evidence that the zero lower bound period was characterized by accommodative monetary policy.

I find evidence that unconventional policy succeeded in stimulating growth in excess of what a federal funds rate of zero would suggest. I infer the implied policy stance based on the estimated SVARs, growth rates of industry revenues, and macroeconomic aggregates used throughout the paper. The method uses the Kalman filter to extract a measure of the interest rate shocks on a quarterly basis from the structural forms of the models in (3). For expositional purposes, consider a bivariate VAR(1) system in structural form

$$B_0 Y_t = B_1 Y_{t-1} + u_t \tag{7}$$

Rewriting as explicit equations for the two variables while assuming a recursive ordering, and letting (i, j) denote the i th row and j th column of the preceding matrix,

$$\begin{aligned} x_t &= B_1(1, 1)x_{t-1} + B_1(1, 2)z_{t-1} + u_{1t} \\ z_t &= -B_0(2, 1)x_t + B_1(2, 2)x_{t-1} + B_1(2, 1)z_{t-1} + u_{2t} \end{aligned} \tag{8}$$

⁴³These impulse responses are presented in the online appendix.

Notice that by construction, the structural shocks u_{1t} and u_{2t} are uncorrelated with each other, and are assumed to be normal with sufficient lag length. This implies that given data and parameters, (8) can be reformulated as a state-space model that can be solved using the Kalman filter out-of-sample. In brief, the Kalman filter minimizes one step ahead prediction errors, optimally weighting the uncertainty of the measurement equation and the uncertainty of the state.

Assume VAR parameters have been solved for using a sample of observed values. Then in state-space form the measurement equation is as follows:

$$x_t = \underbrace{\hat{B}_0(1,1)x_{t-1}}_{\text{deterministic}} + (\hat{B}_1)(1,2)z_{t-1} + u_{1t} \quad (9)$$

while the state equation is defined as:

$$z_t = \underbrace{-\hat{B}_0(2,1)x_t + (\hat{B}_1)(2,2)x_{t-1}}_{\text{deterministic}} + \hat{B}_1(2,1)z_{t-1} + u_{2t} \quad (10)$$

Using the observed series x_t , the unobserved series z_t can be solved for using Kalman filter, both in or out-of-sample, using the estimated VAR parameters in the \hat{B} matrices. Out-of-sample, the Kalman filter is essentially decomposing the forecast errors of structural forecasts of the SVAR equations into an interest rate component and other disturbances.

I make three main changes from the baseline SVARs used throughout the paper.⁴⁴ As shown in the industry impulse responses in Figure 1, the financial sector (NAIC 52) has a starkly different response to a monetary contraction than any other industry, with a large initial increase in revenues, followed by a subsequent decrease to negative growth. In the short run, financial firms can benefit from increased interest rates, and hence larger spreads between short and long-term rates, before the macroeconomic effects of monetary policy depress output. As a result of the strong response of the financial sector, VARs examining the post-1980 subsample often find indeterminate output responses to monetary shocks.⁴⁵ I thus place non-financial corporate output into the SVARs in place of GDP growth,⁴⁶ as the Kalman filter cannot accurately extract monetary shocks following the 1980s if an important measurement equation capturing aggregate demand ceases being informative.

⁴⁴The resulting industry interest sensitivity ranking is highly correlated ($\rho > 0.8$) regardless of these changes, as shown in Section 5.3.

⁴⁵A second reason has been proposed in the monetary VAR literature for the weak response of output to monetary shocks for post-1980 subsamples. [Boivin and Giannoni \(2006\)](#) find that by responding more strongly to inflation, monetary policy has been more effective in counteracting shocks since the 1980s. Since interest rate movements are more systematic and endogenous than in earlier periods, VARs are unable to identify the effects of unsystematic interest rate shocks.

⁴⁶This follows [Lozej \(2012\)](#).

Second, I incorporate the growth rates of government spending and taxation into the SVARs.⁴⁷ Past literature has found that fiscal shocks are an important driver of medium-run macroeconomic dynamics (Rossi and Zubairy, 2011), and controlling for fiscal policy thus results in much more accurate estimates when cross-validating the SVAR model Kalman filtered state estimates of monetary shocks out-of-sample. Furthermore, controlling for fiscal policy is important during the zero bound period, as it is characterized by an unprecedented number of years of fiscal contraction. Finally, industries can be heterogenously affected by fiscal policy, as found in Section 6.2.

Third, I use cumulative Romer and Romer shocks in place of the federal funds rate.⁴⁸ Since the R&R shocks are constructed so as to be relatively free of endogeneity and unpredictable, this allows the state equation to be set up as a random walk, whereby increases or decreases in the monetary stance are agnostically treated as equally likely. This therefore does not impose an implicit Fed reaction function upon the state equation.⁴⁹ This is useful at the zero lower bound, as it shows that state estimates during that period are not driven by previous Federal Reserve behavior imposed in the state equation.

In matrix form, the actual state-space system used can be written in the following manner:

$$\begin{aligned} z_t &= z_{t-1} + u_{6t} \\ X_t &= \hat{C} + \hat{F}(L)W_t + \hat{\Lambda}(L)z_{t-1} + \zeta_t \end{aligned} \tag{11}$$

where z_t , the state, is the cumulative sum of R&R shocks up to quarter t , and X_t is a vector of the variables used in the SVARs besides fiscal variables: non-financial corporate output, industry revenue growth rates, and PCE inflation, all in year-over-year growth rates.⁵⁰ The vector W_t includes all variables in X_t , and also includes fiscal variables. The error term u_{6t} and the vector of errors ζ_t are normally distributed. The term c and vector C are the constants from the right hand side variables of each line in the system. Contemporaneous restrictions are imposed in the following manner:

⁴⁷In order to maintain a parsimonious VAR model while adding fiscal variables I also omit commodity prices.

⁴⁸This shock series ends 2007:Q4.

⁴⁹In practice, the Cholesky-identified monetary shocks are not predicted well in placebo tests with either a random walk state equation or imposing the VAR federal funds rate equation as the state equation.

⁵⁰Note that on the right hand side side, the parameter in \hat{F}_0 for each x_t 's contemporaneous effect on x_t is set to zero.

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_{2,1} & 1 & 0 & 0 & 0 & 0 \\ a_{3,1} & a_{3,2} & 1 & 0 & 0 & 0 \\ a_{4,1} & a_{4,2} & a_{4,3} & 1 & 0 & 0 \\ a_{5,1} & a_{5,2} & a_{5,3} & 0 & 1 & 0 \\ 0 & 0 & a_{6,3} & 0 & a_{6,5} & 1 \end{bmatrix} \begin{bmatrix} \epsilon_{GovtCons,t} \\ \epsilon_{Tax,t} \\ \epsilon_{NFCoutput,t} \\ \epsilon_{IndustryRev,t} \\ \epsilon_{Inflation,t} \\ \epsilon_{R\&Rshocks,t} \end{bmatrix} = \begin{bmatrix} u_{GovtCons,t} \\ u_{Tax,t} \\ u_{NFCoutput,t} \\ u_{IndustryRev,t} \\ u_{Inflation,t} \\ u_{R\&Rshocks,t} \end{bmatrix}$$

The model is essentially Cholesky identified with fiscal variables ordered first, with a few differences. As before, industry revenues are constrained to not affect any other variables either contemporaneously or through lagged parameters. I also impose that the Romer and Romer shocks are not affected by fiscal policy contemporaneously or through lagged parameters.⁵¹

The SVARs are run, yielding structural forms for the federal funds rate, macro variables, and industry revenues.⁵² I then input the parameters and data from both the 1971:Q1-2007:Q4 and post-2008 period into system (11), treating $\hat{F}(L)W_t$ as exogenous disturbances to the measurement equations. Finally, I run the Kalman filter on this system, treating z_t as the unobserved state.

It is important to mention an aspect of the estimated state series z_t . This method does not explicitly capture a market “shadow” interest rate as other papers in the literature have done (Wu and Xia, 2014). The state series after 2008:Q3 is yielding an estimate of cumulative Romer and Romer shocks that would imply the realizations of X_t observed post-zero lower bound. Thus, z_t reveals the amount of monetary accommodation in excess of the Federal Reserve’s typical reaction function as identified by Romer and Romer, which during the zero bound would imply a negative federal funds rate. It is important to note that if the monetary transmission mechanism has been impaired- say by financial disruption- this will result in the state estimate measuring contractionary policy, in spite of the Fed’s actions.

The state estimate is conditional on the pre-zero lower bound VAR dynamics. If the entire structure of the economy has changed- including the relationships between inflation, output, and the federal funds rate- this estimate will not reflect the true monetary stance. In order for the state estimates to be valid, the VAR parameters from before the zero lower bound need to accurately capture dynamics post-2008:Q1.⁵³ This implies that the

⁵¹Feedback effects between fiscal and monetary policy are ignored, as they are not important for the question of interest. This is also consistent with the exclusion of fiscal variables in state-space system (11). These constraints do not affect the results.

⁵²Impulse responses of the macro and industry responses to Romer and Romer shocks are available in the online appendix.

⁵³Section 7.3 provides evidence that this is the case.

distribution of structural shocks since 2008 need to be estimated correctly from before the zero lower bound. It is likely that negative shocks to GDP were underestimated in the pre-zlb sample. Intuitively, however, this would likely bias the state estimates positively rather than negatively. We would expect the Kalman filter to erroneously attribute negative shocks to GDP and industry revenue growth rates to restrictive monetary policy. Due to the direction of expected bias, we can thus infer that, if anything, the state estimate of the R&R shocks likely understates the true monetary stance created by unconventional policy. It is of note that other papers in this literature (Krippner, 2013; Wu and Xia, 2014; Lombardi and Zhu, 2014) also make strong assumptions regarding the relationships between observed variables and unobserved measures of monetary policy during the zero lower bound period, including linearity.

7.2 Results

Figure 7 plots the filtered state equation from System 11.⁵⁴ The estimated state is characterized by negative (expansionary) shocks soon following the incidence of the zero lower bound, which is denoted by a red line. This implies that unconventional policy was able to stimulate corporate industries *in excess* of the Federal Reserve’s previous reaction function, meaning that policy after this point was even more accommodative than what a Taylor-type rule would suggest. This fact helps to explain why it does not seem that interest rate sensitive industries had diminished revenue growth at the zero bound, as it implies that unconventional policy was able to provide monetary accommodation. This result is especially interesting bearing in mind the setup of the state equation: the Romer and Romer shock series was imposed to follow a random walk, meaning that no structure in the state equation is responsible for the measurement of accommodative shocks.

7.3 Placebo Test

The length of the sample allows cross-validation of the results. If the approach accurately captures the stance of policy during the zero bound, it should also accurately capture policy during a subsample in which the VARs have not been estimated. In Figure 8, I

⁵⁴In all charts, standard errors are calculated so as to correct for VAR parameter uncertainty. Steps are as follows: first, 100 new datasets are created using a four quarter moving block bootstrap from the VAR, initialized at 1971:Q1-1971:Q4 values. The VAR is reestimated over each of these new datasets, yielding a distribution of the VAR parameters. The Kalman filter is then run using each estimated VAR in state-space form, with the actual 1971:Q1-2014:Q2 data. The resulting 5th and 95th percentile values of the Kalman root mean squared errors are then presented, thus taking into account both the uncertainty of the VAR parameters and measurement of the unobserved variable.

estimate the SVARs from 1971:Q1-1999:Q3,⁵⁵ then run the Kalman filter over 1971:Q1-2014:Q2 to extract the R&R shocks. A line is drawn at 1999:Q3 to show that after this point, the Kalman estimates are all using VARs out-of-sample, while another reference line is drawn for the incidence of the zero bound. In support of the credibility of the approach, the 1999:Q4-2007:Q4 estimates of the state are very close to the actual R&R shocks over this period, and mirror the results in Figure 7. The VARs thus are capturing time-invariant relationships and do not suffer from overfitting.

7.4 Great Moderation Subsample Analysis

Although the state-space model performs well out-of-sample, one may still wish to see that the method presented finds accommodative shocks using only data from the Great Moderation. Figure 9 plots a similar estimation process as in Figure 7, except that VARs are run on data from 1988:Q1-2007:Q4. The zero bound period is still characterized by accommodative monetary policy.

8 Conclusion

The use of industry data presents a new avenue for examining growth at the zero lower bound. I measure an industry ranking of interest rate sensitivity, and cross-sectionally examine its relationship with revenue growth while Federal Reserve policy was constrained. The approach helps inform current knowledge of monetary policy's real effects by placing into context how industries have grown with respect to the historical record, and shows that interest rate sensitive industries have performed well in the latest recovery. There is no evidence that interest rate sensitive industries have been detrimentally affected by monetary policy, in spite of the large difference between zero and the negative federal funds rate characterized by the Federal Reserve's pre-zero lower bound reaction function. As firms have grown equally well as in previous recoveries,⁵⁶ it must be the case that either unconventional monetary policy had real effects, or other shocks on net caused differential growth in interest rate sensitive industries. However, a thorough evaluation of other plausible shocks leaves monetary policy as the explanation for this differential growth.

The evidence for unconventional monetary policy's beneficial effects is validated through

⁵⁵A variety of breakpoints were experimented with yielding similar results.

⁵⁶This is in aggregate, not cross-sectional terms, as shown in Table 11.

a new time series method measuring monetary accommodation at the zero bound using observed macro and industry data. This quantifies the portion of observed growth attributable to monetary policy. I use estimated structural VAR parameters from before the zero lower bound to predict the most likely monetary shocks given observed data after 2008:Q3. The estimated shocks closely follow those observed in-sample, and are cross-validated with out-of-sample testing. During the zero bound, the measure turns negative significantly. This implies that the zero bound period is characterized by expansionary monetary shocks in excess of typical Federal Reserve behavior, and that unconventional policy stimulated growth as further decreases in the federal funds rate would have. This approach merits further use and could be extended to create an implied stance measured from the macroeconomy, rather than from the public firms examined in this paper.

The results presented in this paper have important ramifications for the conduct of monetary policy at zero interest rates. Despite the inability of the Federal Reserve to further decrease the federal funds rate, there is no evidence that monetary policy has inhibited growth. Standard theory and empirical evidence would have led researchers to believe that announcements of future policies, alteration in relative asset supplies, and quantitative easing would have had limited ability to influence real output ([Walsh, 2014](#)). In contrast, the results show that the US recovery since 2009 compares favorably to past recoveries, and that this is in part due to unconventional monetary policy.

An important caveat to these results is that all data is derived from publicly-listed firms. Public firms are larger than non-public firms, and hence are thought to be less affected by credit constraints and the credit channel ([Gertler and Gilchrist, 1994](#)). From this perspective, we would expect non-public firms to be more affected by restrictive monetary policy. On the other hand, programs such as quantitative easing may disproportionately assist public firms, as they directly benefit from increases in stock and bond valuation. Thus, it is likely that the firms examined in this paper would be the least likely to be affected by the zero bound constraint on policy.

References

- Aizenman, J. and Pasricha, G. K. (2010). The net fiscal expenditure stimulus in the us 2008–2009: Less than what you might think. *VoxEU. org*, 3.
- Aizenman, J. and Pasricha, G. K. (2013). Net fiscal stimulus during the great recession. *Review of Development Economics*, 17(3):397–413.
- Barth, M. J. and Ramey, V. A. (2002). The Cost Channel of Monetary Transmission. In *NBER Macroeconomics Annual 2001, Volume 16*, NBER Chapters, pages 199–256. National Bureau of Economic Research, Inc.
- Bernanke, B. S. and Gertler, M. (1995). Inside the black box: the credit channel of monetary policy transmission. Technical report, National bureau of economic research.
- Bernanke, B. S. and Kuttner, K. N. (2005). What Explains the Stock Market’s Reaction to Federal Reserve Policy? *Journal of Finance*, 60(3):1221–1257.
- Boivin, J. and Giannoni, M. P. (2006). Has monetary policy become more effective? *The Review of Economics and Statistics*, 88(3):445–462.
- Cashin, D., Lenney, J., Lutz, B., and Peterman, W. (2016). Fiscal policy changes and aggregate demand in the u.s. during and following the great recession.
- Chen, S.-S. (2007). Does monetary policy have asymmetric effects on stock returns? *Journal of Money, Credit and Banking*, 39(2-3).
- Christensen, J. H. and Rudebusch, G. D. (2013). Modeling yields at the zero lower bound: Are shadow rates the solution? Citeseer.
- Christiano, L. J., Eichenbaum, M., and Evans, C. L. (1999). Monetary policy shocks: What have we learned and to what end? *Handbook of macroeconomics*, 1:65–148.
- Claessens, S., Tong, H., and Wei, S.-J. (2011). From the Financial Crisis to the Real Economy: Using Firm-level Data to Identify Transmission Channels. In *Global Financial Crisis*, NBER Chapters. National Bureau of Economic Research, Inc.
- Cogan, J. F., Cwik, T., Taylor, J. B., and Wieland, V. (2010). New keynesian versus old keynesian government spending multipliers. *Journal of Economic dynamics and control*, 34(3):281–295.
- Coibion, O. (2012). Are the effects of monetary policy shocks big or small? *American Economic Journal. Macroeconomics*, 4(2):1.
- Davis, S. J., Haltiwanger, J., and Schuh, S. (1998). *Job Creation and Destruction*, volume 1. The MIT Press, 1 edition.
- Dedola, L. and Lippi, F. (2005). The monetary transmission mechanism: Evidence from the industries of five OECD countries. *European Economic Review*, 49(6):1543–1569.

- Ehrmann, M. and Fratzscher, M. (2004). Taking stock: Monetary policy transmission to equity markets. *Journal of Money, Credit, and Banking*, 36(4):719–737.
- Erceg, C. and Levin, A. (2006). Optimal monetary policy with durable consumption goods. *Journal of Monetary Economics*, 53(7):1341–1359.
- Fernald, J. (2014). Productivity and potential output before, during, and after the great recession. Technical report, National Bureau of Economic Research.
- Gertler, M. and Gilchrist, S. (1994). Monetary policy, business cycles, and the behavior of small manufacturing firms. *The Quarterly Journal of Economics*, 109(2):pp. 309–340.
- Gilchrist, S., López-Salido, D., and Zakrajšek, E. (2014). Monetary policy and real borrowing costs at the zero lower bound. Technical report, National Bureau of Economic Research.
- Gorodnichenko, Y. and Weber, M. (2014). Are sticky prices costly? evidence from the stock market. Technical report, American Economic Review.
- Krippner, L. (2013). Measuring the stance of monetary policy in zero lower bound environments. *Economics Letters*, 118(1):135 – 138.
- Lombardi, M. J. and Zhu, F. (2014). A shadow policy rate to calibrate us monetary policy at the zero lower bound.
- Lozej, M. (2012). Financial innovation and firm debt over the business cycle.
- Maio, P. (2013). Another look at the stock return response to monetary policy actions*. *Review of Finance*.
- Martin, R., Munyan, T., and Wilson, B. A. (2014). Potential output and recessions: Are we fooling ourselves? Technical report, IFDP Notes.
- Mian, A. and Sufi, A. (2009). The consequences of mortgage credit expansion: Evidence from the u.s. mortgage default crisis. *The Quarterly Journal of Economics*, 124(4):1449–1496.
- Moscarini, G. and Postel-Vinay, F. (2012). The contribution of large and small employers to job creation in times of high and low unemployment. *The American Economic Review*, 102(6):2509–2539.
- Pagan, A. (1984). Econometric issues in the analysis of regressions with generated regressors. *International Economic Review*, pages 221–247.
- Peersman, G. and Smets, F. (2005). The Industry Effects of Monetary Policy in the Euro Area. *Economic Journal*, 115(503):319–342.
- Rajan, R. G. and Zingales, L. (1998). Financial Dependence and Growth. *American Economic Review*, 88(3):559–86.

- Ramey, V. A. (2015). Macroeconomic shocks and their propagation.
- Ravenna, F. and Walsh, C. E. (2006). Optimal monetary policy with the cost channel. *Journal of Monetary Economics*, 53(2):199–216.
- Romer, C. D. and Romer, D. H. (2004). A new measure of monetary shocks: Derivation and implications. *The American Economic Review*, 94(4):1055–1084.
- Rosenthal, S., Russell, M., Samuels, J. D., Strassner, E. H., and Usher, L. (2014). Integrated industry-level production account for the united states: Intellectual property products and the 2007 naics. *May*, 15:2014.
- Rossi, B. and Zubairy, S. (2011). What is the importance of monetary and fiscal shocks in explaining us macroeconomic fluctuations? *Journal of Money, Credit and Banking*, 43(6):1247–1270.
- Rudebusch, G. D. (2009). The fed’s monetary policy response to the current crisis. *FRBSF economic Letter*.
- Rusnák, M., Havranek, T., and Horváth, R. (2013). How to solve the price puzzle? a meta-analysis. *Journal of Money, Credit and Banking*, 45(1):37–70.
- Steinsson, J. and Nakamura, E. (2014). High frequency identification of monetary non-neutrality. In *2014 Meeting Papers*, number 96. Society for Economic Dynamics.
- Swanson, E. T. and Williams, J. C. (2014). Measuring the effect of the zero lower bound on medium- and longer-term interest rates. *American Economic Review*, 104(10):3154–85.
- Tenreyro, S. and Thwaites, G. (2013). Pushing on a string: Us monetary policy is less powerful in recessions.
- Walsh, C. E. (2014). Monetary policy transmission channels and policy instruments.
- Weise, C. L. (1999). The asymmetric effects of monetary policy: A nonlinear vector autoregression approach. *Journal of Money, Credit and Banking*, 31(1):pp. 85–108.
- Woodford, M. (2012). Methods of policy accommodation at the interest-rate lower bound. In *The Changing Policy Landscape: 2012 Jackson Hole Symposium*. Federal Reserve Bank of Kansas City.
- Wu, J. C. and Xia, F. D. (2014). Measuring the macroeconomic impact of monetary policy at the zero lower bound. Technical report, National Bureau of Economic Research.

Figure 1: Industry orthogonalized responses to one standard deviation federal funds rate shock, 1971:Q1-2008:Q3. The x-axes denote quarters. 90% confidence intervals using circular moving block bootstrap outlined in blue.

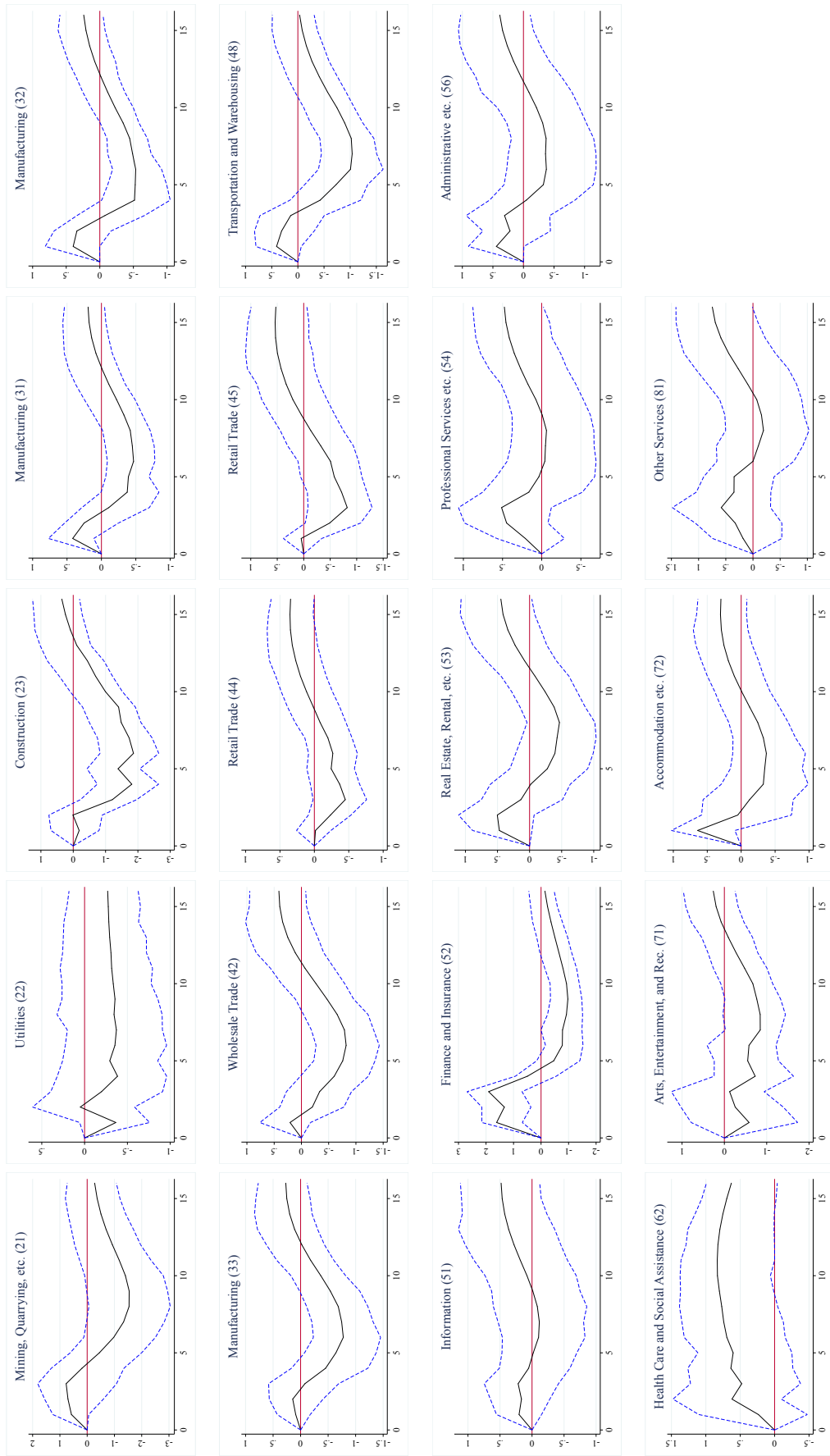


Figure 2: Aggregate orthogonalized responses to one standard deviation shocks by impulse variable, response variable. The x-axes denote quarters. 90% confidence intervals using circular bootstrap outlined in blue.

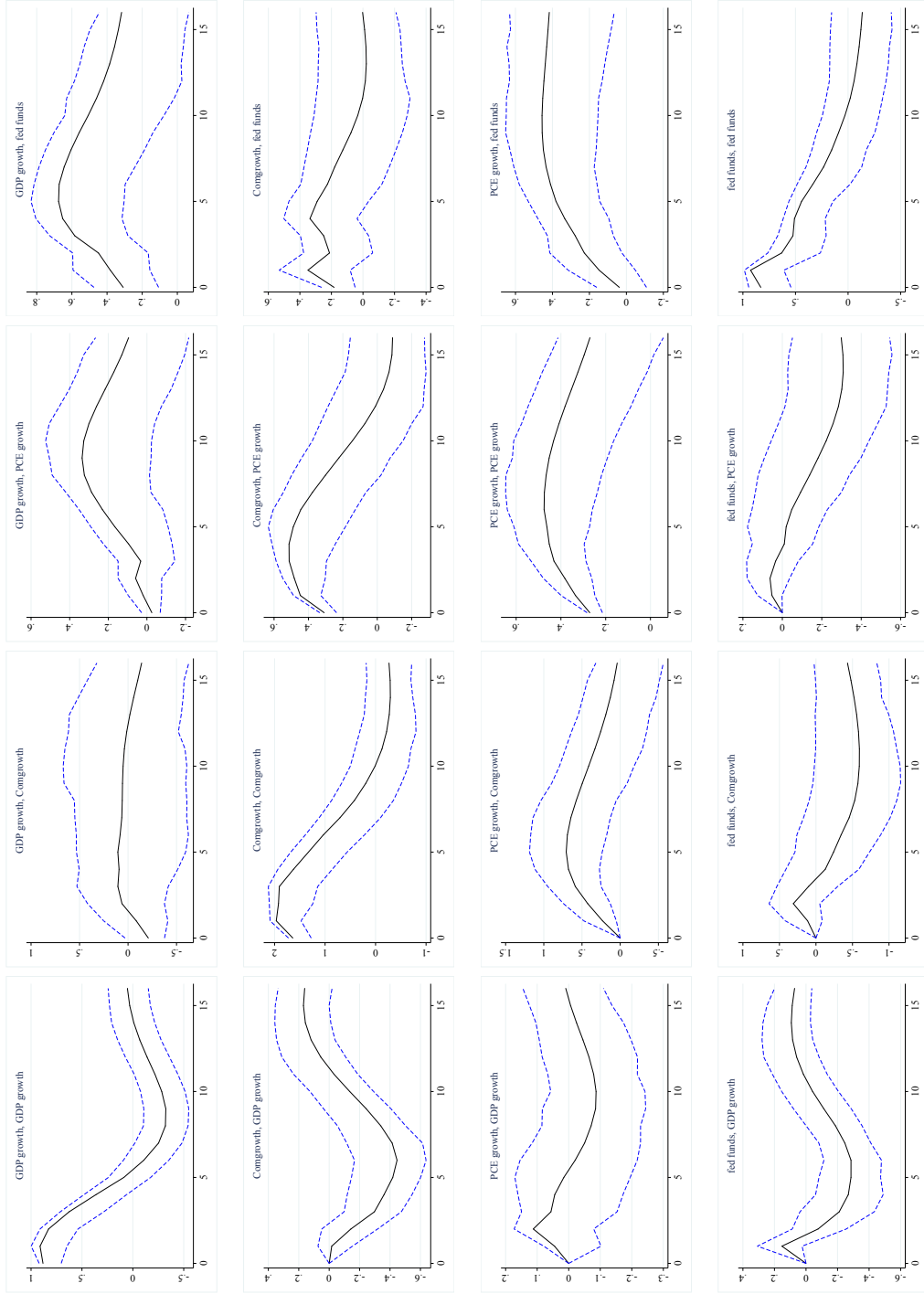


Figure 3: Coefficient estimates of a one standard deviation increase in index sensitivity. Dependent variable: rolling three year revenue growth.

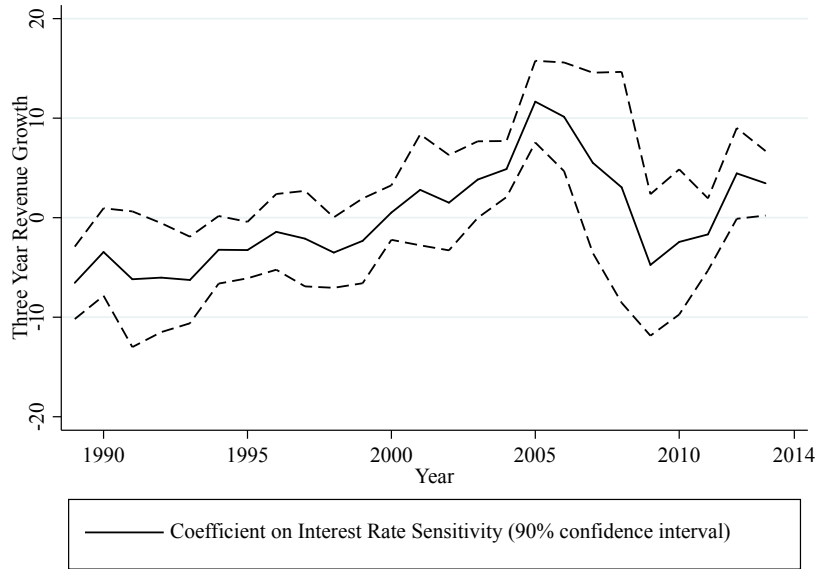
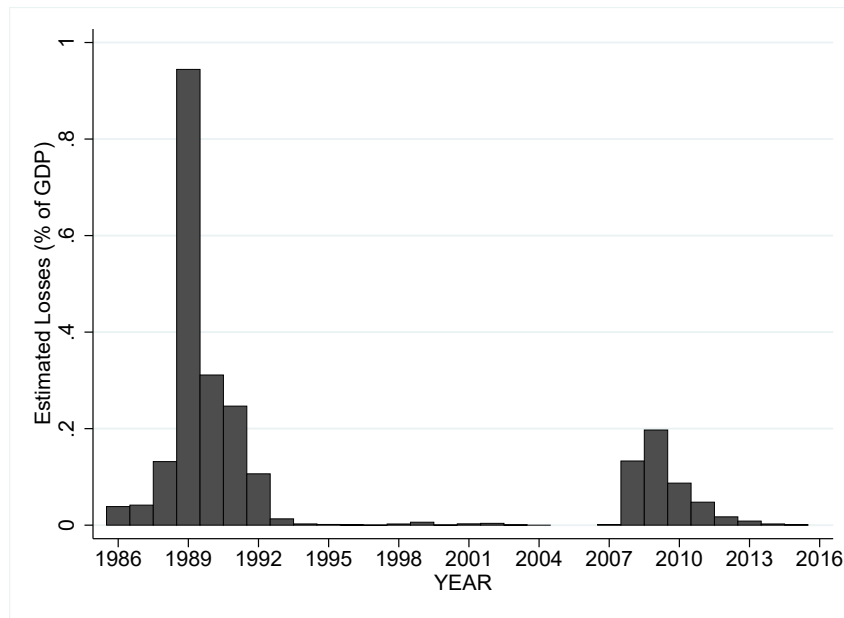
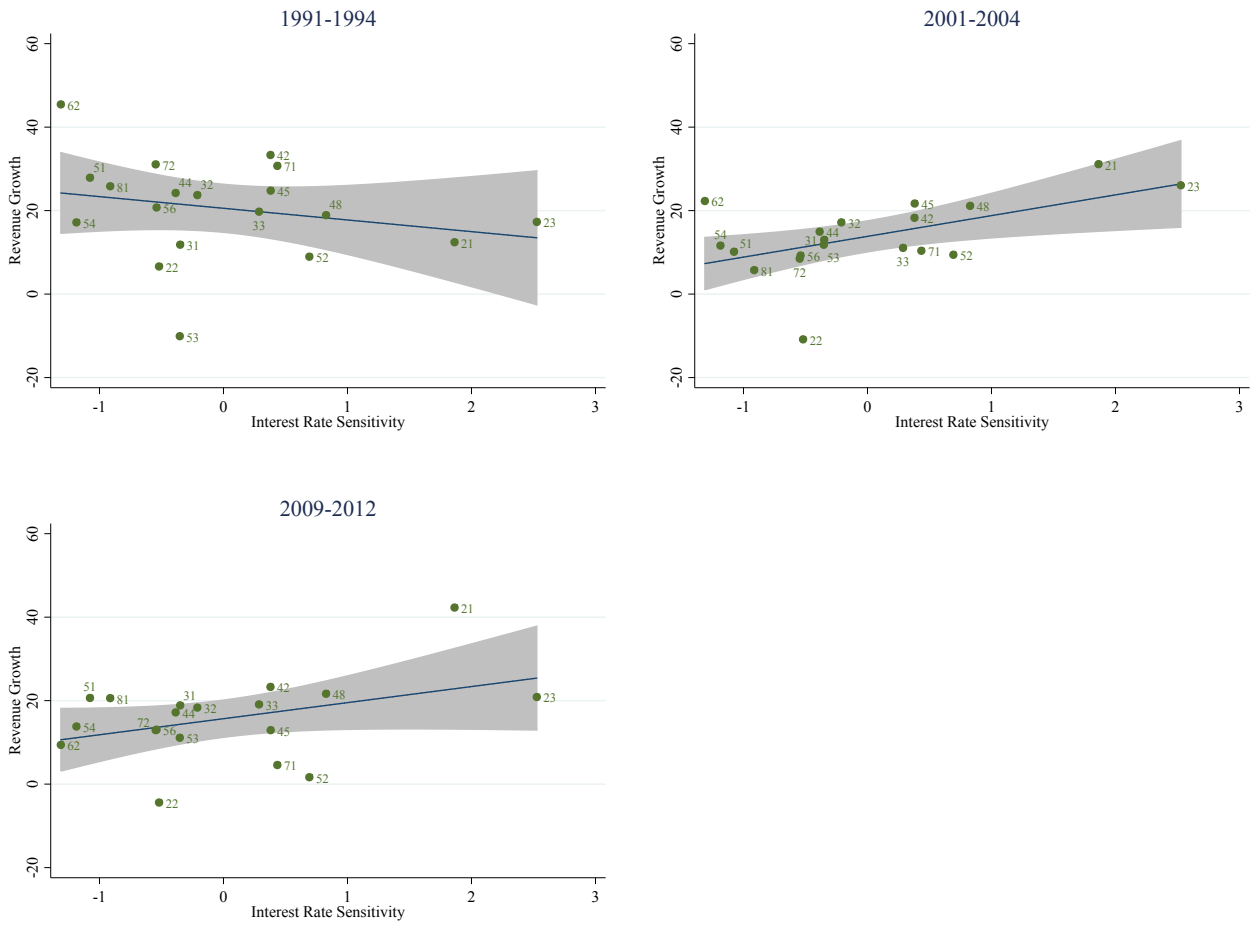


Figure 4: Estimated FDIC Losses Due to Failures and Acquisitions of Banks and Savings Institutions



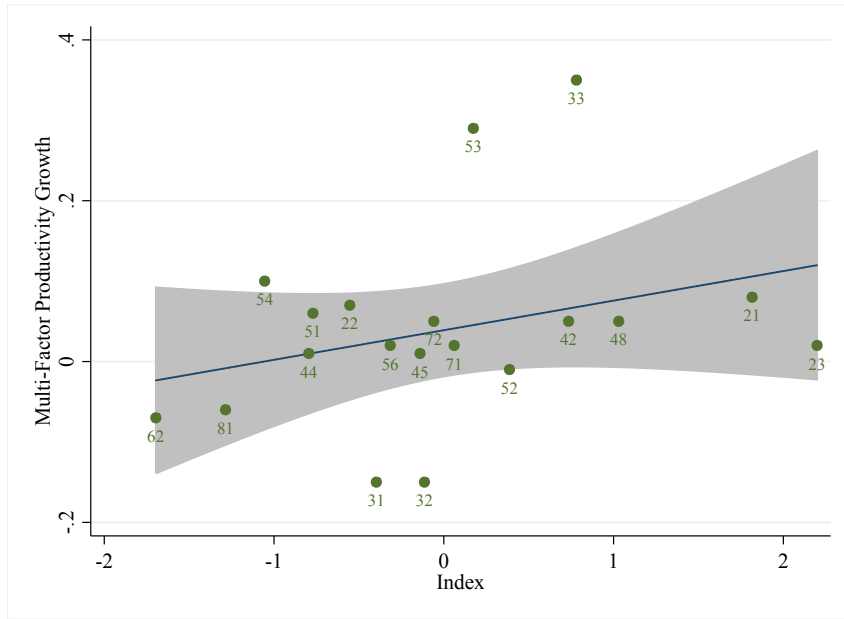
Source: FDIC, Bureau of Economic Analysis, and author's calculations.

Figure 5: Industry growth rates and interest rate sensitivity, 95% confidence intervals in grey. Each industry labeled with North American Industry Classification Code.



Source: Compustat and author's calculations.

Figure 6: Industry Multi-Factor Productivity Growth and Interest Rate Sensitivity Index



Sources: Compustat, Rosenthal et al. (2014), and author's calculations.

Figure 7: Implied Stance of Monetary Policy, Benchmark Estimate

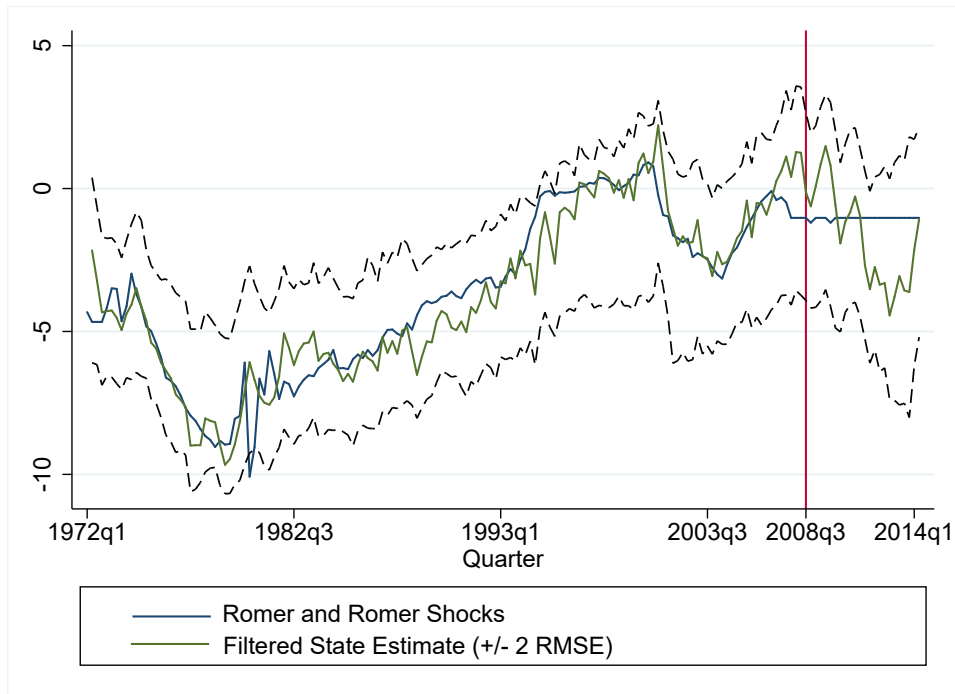
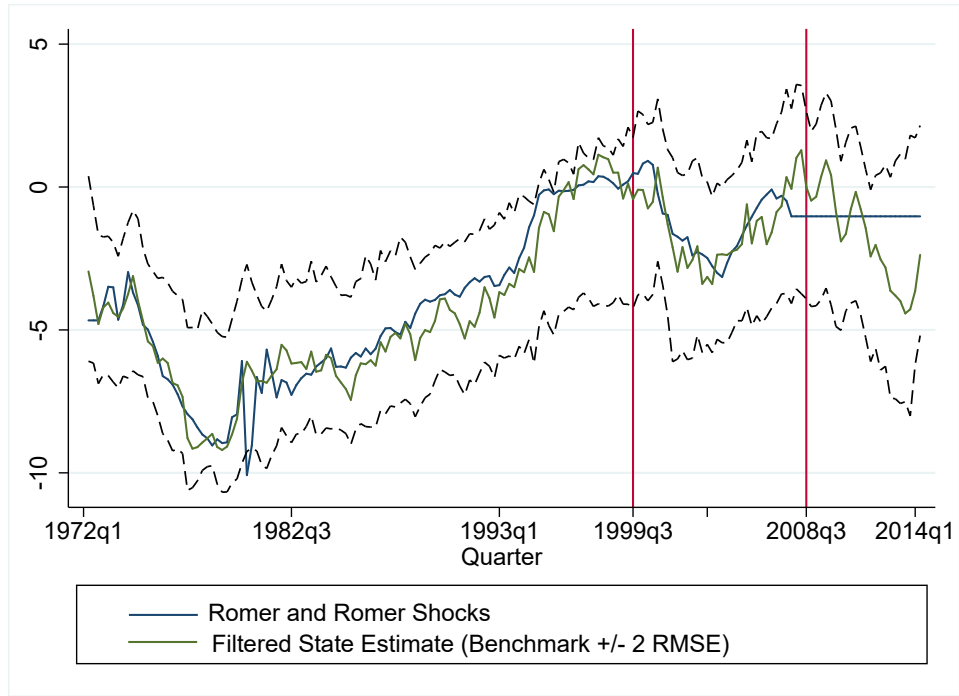


Figure 8: Implied Stance of Monetary Policy: Out-of-Sample Cross-Validation



Estimates following 1999:Q3 are using out-of-sample VAR parameters from before that date.

Figure 9: Implied Stance of Monetary Policy: Great Moderation Data

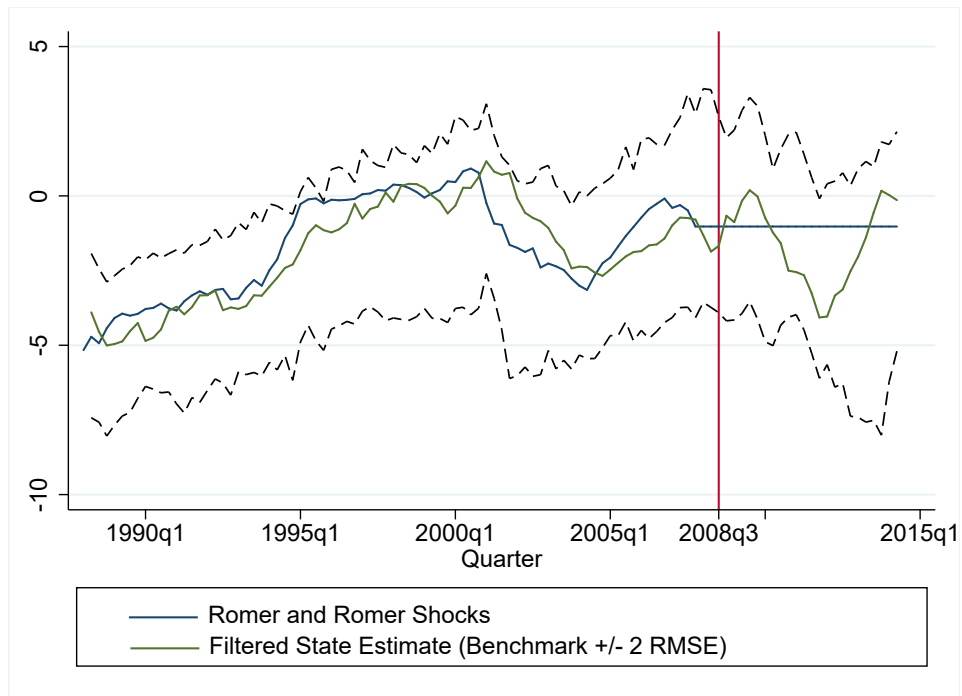


Table 1: Mean Industry Revenue Growth: 1971:Q1-2008:Q3

Name	Naics	Obs	Mean	Median	SD	Min	Max
Agriculture, Forestry, Fishing and Hunting	11	151	4.68	4.50	14.09	-28.81	42.17
Mining, Quarrying, and Oil and Gas Extraction	21	151	8.10	8.84	15.38	-46.51	38.55
Utilities	22	151	4.29	5.07	7.3	-27.84	29.85
Construction	23	151	4.34	4.93	11.32	-24.54	29.98
Manufacturing (mostly non-durables)	31	151	3.45	3.43	4.84	-14.52	14.83
Manufacturing (mostly non-durables)	32	151	6.76	7.40	5.40	-11.17	17.14
Manufacturing (mostly durables)	33	151	6.29	7.11	7.22	-16.93	19.12
Wholesale Trade	42	151	6.00	8.01	7.45	-16.93	17.76
Retail Trade	44	151	6.88	7.09	4.46	-5.07	16.30
Retail Trade	45	151	8.84	8.89	7.07	-5.90	35.57
Transportation and Warehousing	48	151	7.47	8.49	7.24	-15.17	29.37
Transportation and Warehousing	49	151	8.40	8.28	12.26	-19.84	39.49
Information	51	151	11.12	10.29	8.32	-4.21	39.44
Finance and Insurance	52	151	6.50	6.98	8.10	-30.35	24.76
Real Estate and Rental and Leasing	53	151	4.90	5.58	8.16	-13.76	23.18
Professional, Scientific, and Technical Services	54	151	9.55	9.46	7.25	-8.68	27.32
Administrative, Support, Waste Management/Remediation Services	56	151	9.77	10.26	8.23	-11.44	27.16
Educational Services	61	151	14.40	12.72	14.90	-27.3	65.56
Health Care and Social Assistance	62	151	15.11	15.00	8.24	-9.93	32.71
Arts, Entertainment, and Recreation	71	151	10.38	10.88	10.82	-18.50	32.60
Accommodation and Food Services	72	151	6.93	7.39	6.86	-11.99	25.68
Other Services (except Public Administration)	81	151	5.38	4.74	9.71	-17.37	29.18
Total		3322	7.71	7.78	9.78	-46.51	65.56

Source: Compustat and author's calculations.

Table 2: Two Digit NAIC SVAR Interest Rate Sensitivity Index

Two Digit Code	Response (%)	Index	Sector
23	-1.86	2.53	Construction
21	-1.54	1.86	Mining, Quarrying, and Oil and Gas Extraction
48	-1.04	0.83	Transportation and Warehousing
52	-0.97	0.69	Finance and Insurance
71	-0.85	0.43	Arts, Entertainment, and Recreation
45	-0.82	0.38	Retail Trade
42	-0.82	0.38	Wholesale Trade
33	-0.78	0.29	Manufacturing (mostly durables)
32	-0.53	-0.21	Manufacturing (mostly non-durables)
31	-0.47	-0.35	Manufacturing (mostly non-durables)
53	-0.47	-0.35	Real Estate and Rental and Leasing
44	-0.45	-0.39	Retail Trade
22	-0.38	-0.52	Utilities
56	-0.37	-0.54	Administrative, Support, and Waste Management and Remediation Services
72	-0.37	-0.55	Accommodation and Food Services
81	-0.19	-0.91	Other Services (except Public Administration)
51	-0.11	-1.08	Information
54	-0.06	-1.19	Professional, Scientific, and Technical Services
62	0	-1.31	Health Care and Social Assistance

Table 3: Real Revenue Growth, Baseline Specification

	(1)	(2)	(3)	(4)
Index	-0.028 (1.779)	0.696 (2.545)	0.531 (2.361)	0.885 (2.653)
Index·2012	2.442 (3.692)	2.346 (2.970)	2.611 (3.087)	2.617 (3.096)
Elasticity·94		4.489** (1.842)	3.943** (1.718)	4.311** (1.767)
Elasticity·09		-0.586 (3.628)	-0.050 (3.503)	0.121 (3.349)
Elasticity·12		1.088 (4.260)	0.788 (4.149)	1.091 (3.893)
Emp·94			-5.874*** (0.954)	-5.830*** (0.960)
Emp·09			0.531 (0.675)	0.667 (0.701)
Emp·12			-0.027 (0.685)	0.080 (0.671)
Secular Trend				-3.490 (5.083)
1991-1994	19.222*** (2.146)	12.532*** (3.862)	17.787*** (3.907)	20.181*** (3.904)
2001-2004	12.107*** (1.494)	12.992* (6.831)	10.295 (6.557)	12.699** (5.717)
2009-2012	14.887*** (3.183)	13.263 (7.984)	13.276 (8.152)	15.496* (8.211)
Observations	17,723	17,723	16,480	16,480
Adjusted R-squared	0.068	0.069	0.067	0.068

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors clustered at NAIC 2 digit level in parentheses.

Table 4: Real Revenue Growth: Pre-trends

	(1)	(2)	(3)	(4)
Index	-4.589 (4.145)	-4.932 (2.847)	-4.318* (2.340)	-3.729* (2.075)
Index·2009-2009	-0.961 (3.080)	-2.729 (2.973)	-3.677 (2.592)	-3.693 (2.548)
Observations	18,333	18,333	16,313	16,313
Adjusted R-squared	0.063	0.064	0.041	0.042

**** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors clustered at NAIC 2 digit level in parentheses. Time indicators not shown. Column (2) controls for industry-level GDP elasticity, column (3) controls for initial log employment, and Column (4) controls for secular industry trends as in Table 3.

Table 5: Real Revenue Growth: Controlling for Mean Reversion

	(1)	(2)	(3)	(4)
Index	1.833 (1.340)	2.134 (1.855)	2.582 (1.822)	3.043 (1.855)
Index·2012	0.913 (3.139)	1.497 (2.692)	1.532 (2.679)	1.526 (2.678)
Lagged Growth	0.046*** (0.016)	0.047*** (0.016)	0.048*** (0.014)	0.047*** (0.014)
Observations	14,734	14,734	14,157	14,157
Adjusted R-squared	0.041	0.042	0.053	0.054

**** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors clustered at NAIC 2 digit level in parentheses. Time indicators not shown. Column (2) controls for industry-level GDP elasticity, column (3) controls for initial log employment, and Column (4) controls for secular industry trends as in Table 3.

Table 6: Real Revenue Growth: Bootstrapped Standard Errors Accounting for Generated Regressors

	Clustered	Bootstrapped
Index	1.087 (1.701)	(2.248)
Index·2012	2.762 (2.947)	(3.439)
1991-1994	20.554*** (2.342)	(2.637)
2001-2004	13.827*** (2.342)	(1.931)
2009-2012	15.671*** (2.342)	(2.208)
Observations	57	57
Adjusted R-squared	0.731	

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Bootstrap procedure described in text.

Table 7: Romer and Romer Alternative Shock Measures

	Baseline	R&R Shocks	W/ NFC and Fiscal Variables
Baseline	1.00		
R&R	0.85	1.00	
R&R NFC	0.80	0.73	1.00

Column (2) uses an index measured with cumulative Romer and Romer shocks in place of the federal funds rate. Column (3) uses the cumulative Romer and Romer shocks in place of the federal funds rate, non-financial corporate output in place of GDP growth, includes government consumption and investment ordered first, includes government tax revenues ordered second, and excludes commodity prices.

Table 8: Real Revenue Growth, Romer and Romer Shock Measures

	(1)	(2)	(3)
Index	0.885 (2.653)	0.662 (1.962)	2.481 (9.835)
Index·2012	2.617 (3.096)	2.741 (2.652)	4.937 (12.467)
1991-1994	20.181*** (3.904)	19.771*** (4.096)	18.461** (7.380)
2001-2004	12.699** (5.717)	12.671** (5.552)	10.991 (9.181)
2009-2012	15.496* (8.211)	20.098** (9.471)	11.716 (9.860)
Observations	16,480	16,480	16,480
Adjusted R-squared	0.068	0.068	0.067

*** p<0.01, ** p<0.05, * p<0.1. Industry clustered standard errors in parentheses. Column (1) uses the baseline sensitivity index. Column (2) uses an index measured with cumulative Romer and Romer shocks in place of the federal funds rate. Column (3) uses the cumulative Romer and Romer shocks in place of the federal funds rate, non-financial corporate output in place of GDP growth, includes government consumption and investment ordered first, includes government tax revenues ordered second, and excludes commodity prices.

Table 9: Labor Productivity Growth

	(1)	(2)	(3)
Index	0.771 (2.085)	0.391 (2.892)	0.466 (3.190)
Index·2012	-0.705 (3.019)	0.451 (2.759)	0.454 (2.757)
1991-1994	13.643*** (2.403)	8.393 (5.007)	8.933** (3.125)
2001-2004	4.091 (2.494)	9.805* (5.334)	10.368** (3.865)
2009-2012	11.251*** (1.139)	9.226** (3.215)	9.742*** (3.359)
Observations	15,912	15,912	15,912
Adjusted R-squared	0.038	0.040	0.040

*** p<0.01, ** p<0.05, * p<0.1. Industry clustered standard errors in parentheses. Control variable coefficients omitted from table. Column (2) controls for sectoral GDP elasticity. Column (3) controls for industry-specific growth trends.

Table 10: Real Revenue Growth: Controlling for Fiscal Policy

	(1)	(2)	(3)
Index	-0.028 (1.779)	0.553 (2.309)	0.814 (2.553)
Index·2012	2.442 (3.692)	0.639 (2.671)	3.228 (2.641)
FiscalIndex		2.021 (2.963)	1.976 (3.561)
FiscalIndex·2012		-5.808* (2.815)	-9.499*** (2.697)
1991-1994	19.222*** (2.146)	19.068*** (2.128)	22.195*** (7.546)
2001-2004	12.107*** (1.494)	11.833*** (1.769)	14.105** (6.374)
2009-2012	14.887*** (3.183)	15.191*** (3.061)	8.006 (7.970)
Observations	17,723	17,723	16,480
Adjusted R-squared	0.068	0.069	0.070

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors clustered at NAIC 2 digit level in parentheses. Column (3) controls for sectoral GDP elasticity, initial log employment, and industry-specific growth trends.

Table 11: Summary Statistics: Key Dependent Variables

Real Revenue Growth						
Years	Obs	Mean	Median	Std. Dev.	Min	Max
1991-1994	5987	19.27	15.00	59.89	-199.68	199.58
2001-2004	6778	12.12	11.45	60.12	-199.81	199.88
2009-2012	5124	15.12	13.22	52.11	-199.91	199.87
Employment Growth						
1991-1994	5249	13.65	8.08	56.55	-200	200
2001-2004	6144	4.09	4.20	52.11	-200	200
2009-2012	4668	11.26	9.01	44.21	-200	200

Appendix to “How Effective is Monetary Policy at the Zero Lower Bound? Identification Through Industry Heterogeneity”

Arsenios Skaperdas
For Online Publication

Robustness

Alternative Interest Rate Sensitivity Indices

As shown in the paper, industry orthogonalized impulse responses exhibit variation at varied quarters. I use alternative measure of index construction to test for the importance of this variation. Table 1 reveals that constructing the index using 7 quarter structural impulse response point estimates, or 16 quarter cumulative responses, result in highly correlated industry orderings to the baseline using the minimum point estimate responses. Table 2 shows that the 2012 interest rate sensitivity coefficient interactions are in fact positive and significant in the second-stage regressions. With these definitions of interest rate sensitivity, the zero lower bound recovery is actually stronger than previous recoveries in interest rate sensitive industries.¹

The ordering of the SVARs was chosen in accordance with the literature. However, the index and the second-stage results are unaffected by ordering. Specifying the SVARs as normally recursively identified VARs, where industry revenues affect the macro variables, results in a highly correlated index. Furthermore, rearranging the ordering of the VARs leaves all results unchanged. Table 3 presents the index correlations resulting from different orderings, while Table 4 presents the second stage estimates.

Table 5 presents correlations of the indices with a number of other specifications of the SVARs, while Table 6 presents the second-stage results. Column (2) includes indicators for each quarter to control for any additional seasonality in the year over year growth rates. Column (3) omits commodity prices from the SVARs. Column (4) runs the SVARs and second-stage estimates including the three industries that are omitted in the paper due to the fact that they have few firm-observations per quarter (Figure 2) and resulting

¹Part of this is due to the fact that NAICS 52, Finance and Insurance, is ranked as less interest rate sensitive using the alternative measures, as this industry has an initial increase in revenues in response to a contractionary monetary shock. Since this industry did poorly following the financial crisis, ranking it as less sensitive makes the 2012 index interaction coefficient more positive.

noisy time series (Figures 3). Column (5) constrains industry revenues to not affect the macroeconomic aggregates, and with industry revenues ordered last. In all cases, the industry indices are highly correlated, and the second-stage estimates are largely unchanged.

It is thought the transmission mechanism of monetary policy has changed through time, particularly since the early 1980s. In evaluating the transmission mechanism, [Barth and Ramey \(2002\)](#) find evidence that the cost channel of monetary policy decreased after the Volcker period. During the 1970s, the financial structure of credit markets was affected by deregulation and the regional de-segmentation of banking markets [Friedman \(1986\)](#). The US exchange rate regime also moved from fixed to floating. At times before the 1980s, the Federal Reserve sought to directly limit the amount of bank lending ([Romer and Romer, 1989](#)). Finally, the Fed also officially targeted monetary aggregates rather than interest rates from 1979-1982. In spite of evidence for changes in the monetary transmission mechanism, Table 5 shows that the index is still correlated ($\rho = 0.66$) when using only the post-1988:Q1 subsample for VAR index construction. Column (6) of Table 6 also shows the second-stage results are unaffected. In fact, using only more recent data for the SVAR index suggests that interest rate sensitive industries had greater revenue growth during the recovery at the zero lower bound.²

As a last check on the VAR results, the 2012 period compares favorably regardless of lag length selections, though the magnitude and significance of the index coefficient do fluctuate (Tables 7 and 8). In conclusion, the VARs are remarkably robust across all specifications in the outcome of the industry ordering, and the second-stage results.

Further Second-Stage Robustness

The results hold using a balanced panel of firms, that is, using firms that exist in all recovery years. This alleviates concerns associated with bias due to firm entry and exit. As shown in Table 9, the coefficient on the index from 2009-2012 is not statistically different from zero.

One possible criticism of all regressions presented thus far is that firm-level data is examined while the index varies at only the industry level. Since only 19 industries are used, the effective sample size of the differences-in-differences estimates is more closely approximated as 19 for each recovery, rather than thousands of firms. Although standard errors are clustered at the industry level, the small number of clusters means that clustered

²This is partly due to the fact that Finance and Insurance is ranked much less sensitive in the post-1988 subsample, and this industry, as expected, fared poorly following the financial crisis.

standard errors may overstate significance.

One way to evaluate whether this problem has merit is to take industry averages, and completely ignore the firm dimension in the differences-in-differences specification. Table 10 presents the results from this process. The coefficients on the index recovery interactions give similar estimates. In addition, the R^2 increases to 70 – 73% from the 7 – 8% observed in baseline firm-level regressions.

The 2009-2012 results compare favorably to previous recoveries when dropping industries one at a time (Table 11), though dropping Mining, Quarrying, and Oil and Gas Extraction (21) does decrease the zero lower bound coefficient. However, it is still not statistically different from previous recoveries. In addition, it is of note that when dropping the financial industry (NAIC 52), the 2009-2012 period is characterized by significantly greater revenue growth in interest rate sensitive industries. This is notable, as we would expect the financial industry to recover slowly after the financial crisis; one could make the case that dropping the financial industry would be more sensible for the entire paper. In that case, most regressions would show increased growth of interest rate sensitive industries at the zero lower bound.

VAR Results for Identifying the Policy Stance and Industry Effects of Fiscal Policy

Figure 4 presents the industry responses to a monetary shock from VARs with cumulative Romer and Romer shocks in place of the federal funds rate, as described in Section 7 of the paper. These VARs are used for identifying the policy stance and for identifying industry sensitivity to fiscal policy. Macro aggregate responses, shown in Figure 5, are as expected, with the exception of counterintuitive responses to tax shocks.³ However, the estimated Kalman filtered R&R shocks are similar when omitting tax revenues from the VAR.⁴ Figure 6 presents the industry responses to a government spending shock, while Table 12 presents the resulting index based on Figure 6's standardized cumulative impulse responses.

³VARs with government spending, tax receipts, and GDP growth over this time period result in similar impulse responses.

⁴Ilzetzki (2011) also finds similar results whether controlling or not for tax revenues in VARs estimating effects of fiscal spending.

Table 1: Cross-correlation Table: Alternative Index Construction

Baseline	1.00		
Sirf 7 quarters	0.93	1.00	
Csirf 16 quarters	0.88	0.96	1.00

Sirf 7 quarters refers to the 7 quarter structural impulse response point estimate. Csirf 16 quarters refers to the 16 quarter cumulative structural impulse response.

Table 2: Alternative Index Construction

	(1)	(2)	(3)
	Baseline	Sirf7	Csirf16
Index	0.885 (2.653)	-0.880 (2.898)	-1.456 (3.008)
Index·2012	2.617 (3.096)	5.446* (2.890)	6.867** (2.914)
1991-1994	20.181*** (3.904)	20.832*** (3.827)	21.306*** (4.123)
2001-2004	12.699** (5.717)	13.571** (5.942)	13.979** (5.741)
2009-2012	15.496* (8.211)	14.700* (8.391)	14.180 (9.166)
Observations	16,480	16,480	16,480
Adjusted R-squared	0.068	0.068	0.068

*** p<0.01, ** p<0.05, * p<0.1. Industry clustered standard errors in parentheses. Baseline refers to 16 quarter minimum response as described in text. Csirf and sirf indicate cumulative structural and structural impulse responses respectively.

Table 3: Cross-correlation Table: Different VAR Orderings

	Baseline	GDP FF P	FF GDP P	P FF GDP
Baseline	1.00			
GDP FF P	0.91	1.00		
FF GDP P	0.93	0.90	1.00	
P FF GDP	0.93	0.82	0.98	1.00

All VARs contain four lags and a constant. GDP refers to real gross domestic product growth and industry revenue block, P refers to price block, and FF refers to federal funds rate.

Table 4: Real Revenue Growth, Different VAR Orderings

	(1) Baseline	(2) GDP FF P	(3) FF GDP P	(4) P FF GDP
Index	0.885 (2.653)	0.348 (2.759)	0.155 (2.468)	0.030 (2.420)
Index·2012	2.617 (3.096)	3.437 (3.136)	6.451** (2.267)	6.840*** (2.370)
1991-1994	20.181*** (3.904)	20.501*** (4.131)	20.354*** (3.978)	20.476*** (4.092)
2001-2004	12.699** (5.717)	13.115** (5.722)	12.999** (5.775)	13.125** (5.875)
2009-2012	15.496* (8.211)	16.908* (8.906)	13.001* (7.361)	11.095 (7.189)
Observations	16,480	16,480	16,480	16,480
Adjusted R-squared	0.068	0.068	0.069	0.069

*** p<0.01, ** p<0.05, * p<0.1

*** p<0.01, ** p<0.05, * p<0.1. Industry standard errors clustered in parentheses.

Table 5: Cross-correlation Table: Alternative Specifications

	Baseline	Qrtr Ind	No Com	Post-1988
Baseline	1.00			
Quarter Indicators	1.00	1.00		
No Commodity Prices	0.98	0.97	1.00	
Post-1988	0.66	0.64	0.65	1.00

Table 6: Alternative Specifications

	(1)	(2)	(3)	(4)	(5)
	Baseline	Quarter Dummies	No Commodity Prices	All Sectors	Post 1988Q1
iIndex	0.885 (2.653)	0.704 (2.685)	1.359 (2.593)	-1.190 (2.953)	0.006 (2.463)
Index·2012	2.617 (3.096)	1.531 (3.190)	5.050 (2.960)	-2.647 (3.212)	6.101*** (2.010)
1991-1994	20.181*** (3.904)	20.198*** (3.913)	20.299*** (3.809)	20.405*** (4.008)	20.325*** (4.109)
2001-2004	12.699** (5.717)	12.714** (5.760)	12.902** (5.401)	12.694** (5.632)	12.971** (5.826)
2009-2012	15.496* (8.211)	16.387* (8.576)	13.385 (7.942)	16.568* (8.852)	17.232** (8.052)
Observations	16,480	16,480	16,480	16,634	16,480
Adjusted R-squared	0.068	0.067	0.069	0.068	0.069

*** p<0.01, ** p<0.05, * p<0.1. Industry standard errors clustered in parentheses.

Table 7: Cross-correlation Table: Alternative Lag Lengths

	Baseline	2 Lags	3 Lags	5 Lags
Baseline	1.00			
2 Lags	0.94	1.00		
3 Lags	0.96	0.96	1.00	
5 Lags	0.93	0.90	0.93	1.00

Table 8: Real Revenue Growth, Alternative Lag Lengths

	Baseline (4 Lags)	2 Lags	3 Lags	5 Lags
Index	0.885 (2.653)	0.337 (2.369)	0.906 (2.792)	-0.431 (2.347)
Index·2012	2.617 (3.096)	5.450** (2.369)	3.513 (2.917)	0.958 (2.802)
1991-1994	20.181*** (3.904)	20.500*** (3.845)	20.249*** (3.739)	20.323*** (4.192)
2001-2004	12.699** (5.717)	13.134** (5.688)	12.806** (5.601)	13.090** (5.707)
2009-2012	15.496* (8.211)	14.167* (8.051)	15.366 (8.925)	17.470* (9.813)
Observations	16,480	16,480	16,480	16,480
Adjusted R-squared	0.068	0.069	0.068	0.067

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors clustered at NAIC 2 digit level in parentheses. Control variable coefficients omitted from table.

Table 9: Real Revenue Growth, Balanced Subsample

	(1)	(2)	(3)	(4)
Index	1.927 (3.025)	2.985 (3.362)	2.689 (3.111)	3.058 (2.674)
Index·2012	1.450 (2.170)	1.129 (2.116)	1.299 (2.042)	1.181 (2.082)
1991-1994	22.126*** (2.604)	13.623** (4.952)	20.162*** (4.572)	27.410*** (4.169)
2001-2004	10.778*** (2.983)	7.537 (9.212)	7.480 (9.472)	14.600* (7.028)
2009-2012	8.862*** (2.707)	5.900 (5.660)	5.592 (6.067)	12.620** (5.398)
Observations	5,185	5,185	4,965	4,965
Adjusted R-squared	0.107	0.111	0.113	0.118

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors clustered at NAIC 2 digit level in parentheses. Control variable coefficients omitted from table. Column (2) controls for sectoral GDP elasticity. Column (3) controls for initial firm employment. Column (4) controls for industry-specific growth trends.

Table 10: Real Revenue Growth, Industry-Level Data

	(1)	(2)	(3)	(4)
Index	1.087 (1.701)	1.398 (1.774)	1.615 (1.829)	1.643 (1.857)
Index·2012	2.762 (2.947)	2.344 (3.073)	2.233 (3.228)	2.260 (3.267)
1991-1994	20.554*** (2.342)	16.403*** (4.485)	9.882 (7.427)	10.328 (7.977)
2001-2004	13.827*** (2.342)	13.630*** (4.485)	14.007* (7.812)	14.196* (7.979)
2009-2012	15.671*** (2.342)	16.424*** (4.524)	15.503* (7.859)	15.679* (8.014)
Observations	57	57	57	57
Adjusted R-squared	0.731	0.721	0.711	0.705

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors clustered at NAIC 2 digit level in parentheses. Control variable coefficients omitted from table. Column (2) controls for sectoral GDP elasticity. Column (3) controls for initial firm employment. Column (4) controls for industry-specific growth trends.

Table 11: Real Revenue Growth: Industries Dropped One at a Time

Industry	All	21	22	23	31	32	33	42	44	45	51	52	53	54	55	56	62	71	72	81
Index	0.89 (2.653)	0.10 (2.553)	-1.97 (2.137)	0.61 (3.429)	0.83 (2.738)	1.35 (2.551)	1.30 (2.850)	0.63 (2.631)	1.31 (2.737)	0.72 (2.657)	0.76 (2.580)	1.97 (2.623)	0.63 (2.696)	0.41 (2.773)	0.89 (2.653)	0.86 (2.661)	2.90 (2.028)	0.89 (2.657)	1.08 (2.788)	0.88 (2.732)
Index:2012	2.62 (3.096)	-0.04 (2.394)	1.85 (2.967)	3.29 (4.208)	2.91 (3.070)	2.40 (2.987)	0.90 (3.186)	2.81 (3.153)	2.48 (3.102)	2.87 (3.134)	3.84 (3.339)	5.15* (2.694)	2.72 (3.091)	3.31 (3.302)	2.62 (3.096)	2.63 (3.112)	1.15 (2.829)	2.61 (3.104)	2.52 (3.108)	2.71 (3.115)
Observations	16,480	15,808	15,714	16,259	15,837	14,647	12,353	15,890	16,032	16,200	14,868	13,917	16,013	15,759	16,480	16,145	16,185	16,372	16,142	16,410
R-squared	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.07	0.07	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

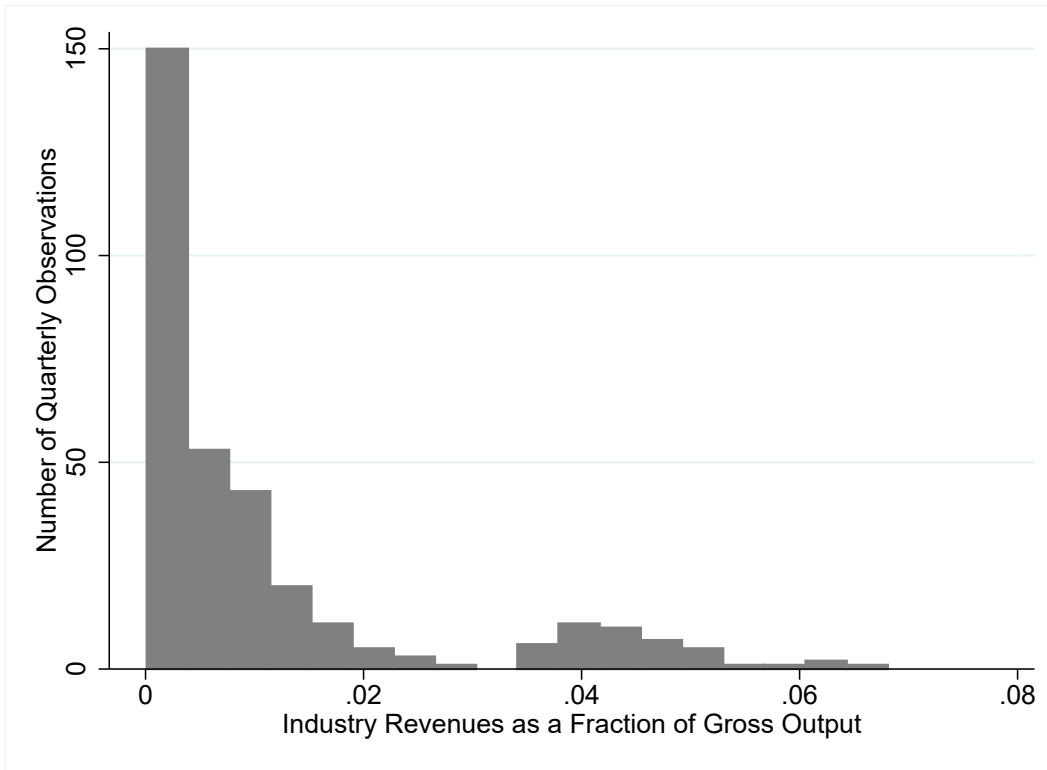
*** p<0.01, ** p<0.05, * p<0.1. Industry clustered standard errors in parentheses. Column headings denote NAIC industry dropped from regression.

Table 12: Two Digit NAIC SVAR Government Spending Sensitivity Index

Two Digit Code	Fiscal Index	Sector
21	-2.49	Mining, Quarrying, and Oil and Gas Extraction
22	-1.81	Utilities
71	-1.33	Arts, Entertainment, and Recreation
31	-0.68	Manufacturing
42	-0.48	Wholesale Trade
81	-0.24	Other Services (except Public Administration)
48	-0.06	Transportation and Warehousing
32	0.12	Manufacturing
53	0.16	Real Estate and Rental and Leasing
51	0.16	Information
23	0.24	Construction
33	0.28	Manufacturing
52	0.53	Finance and Insurance
56	0.64	Administrative and Support and Waste Management and Remediation Services
54	0.72	Professional, Scientific, and Technical Services
45	0.78	Retail Trade
72	1.06	Accommodation and Food Services
62	1.16	Health Care and Social Assistance
44	1.23	Retail Trade

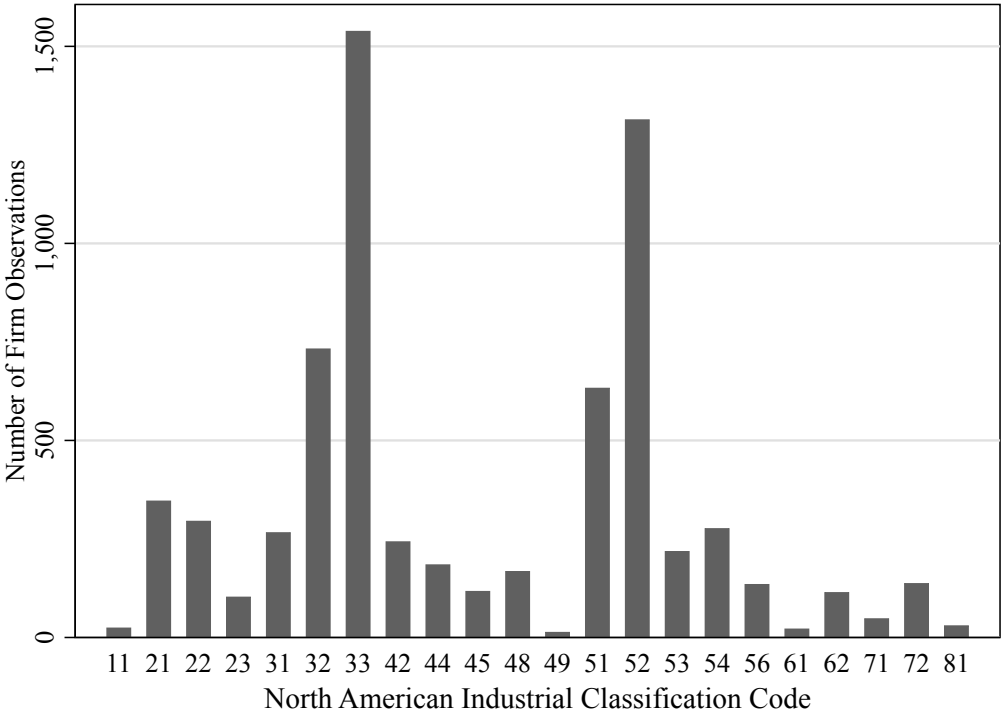
The industries ranked most negative have negative revenue responses to expansionary fiscal shocks. The industries ranked most positive have positive revenue responses to expansionary fiscal shocks.

Figure 1: Quarterly Industry Revenues: 2005Q1-2008Q3.



This figure shows that individual industry revenues tend to be a small portion of aggregate revenues. Sources: Compustat, Bureau of Economic Analysis, and author's calculations.

Figure 2: Average Number of Quarterly Firm Observations by North American Industrial Classification Code, 1970:Q1-2008:Q3



Source: Compustat and author's calculations.

Figure 3: Constructed Industry Time Series

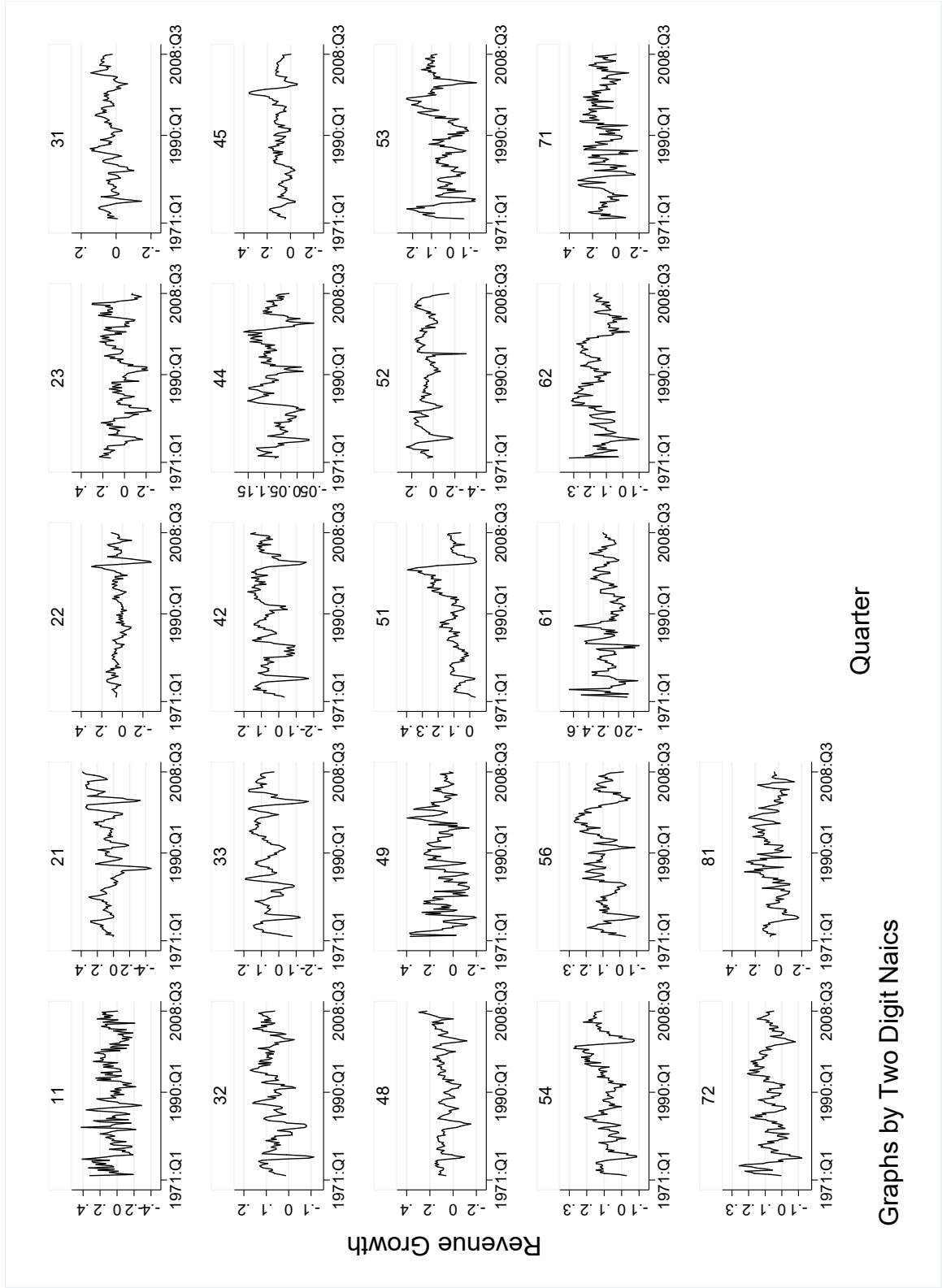


Figure 4: Industry impulse responses to one standard deviation R&R shocks. The x-axes denote quarters. 90% confidence intervals using circular moving bootstrap outlined in blue. Full specification described in text.

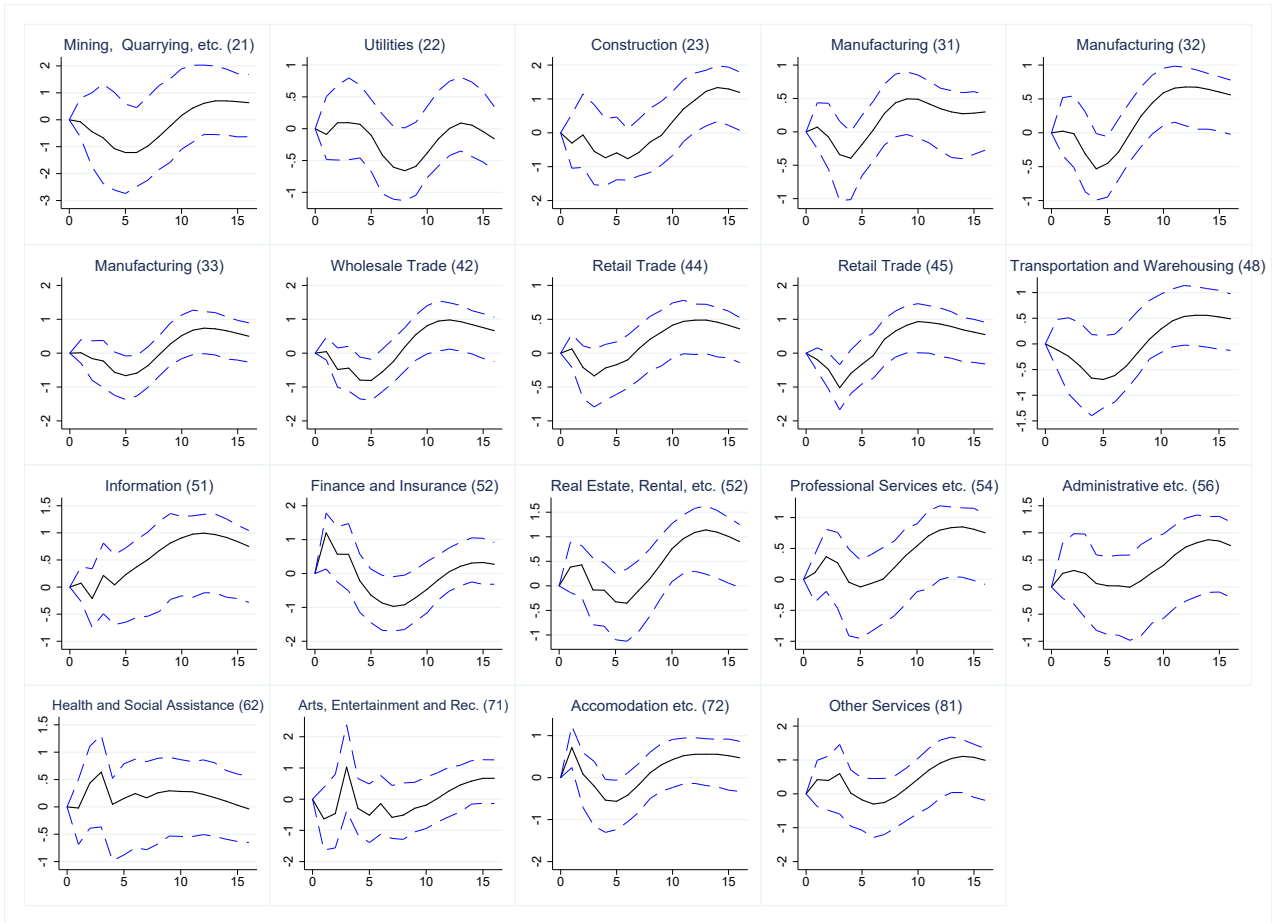


Figure 5: Aggregate impulse responses to one standard deviation shocks using R&R Shocks. The x-axes denote quarters. 90% confidence intervals using circular moving bootstrap outlined in blue. Charts labeled by impulse, response. Full specification described in text.

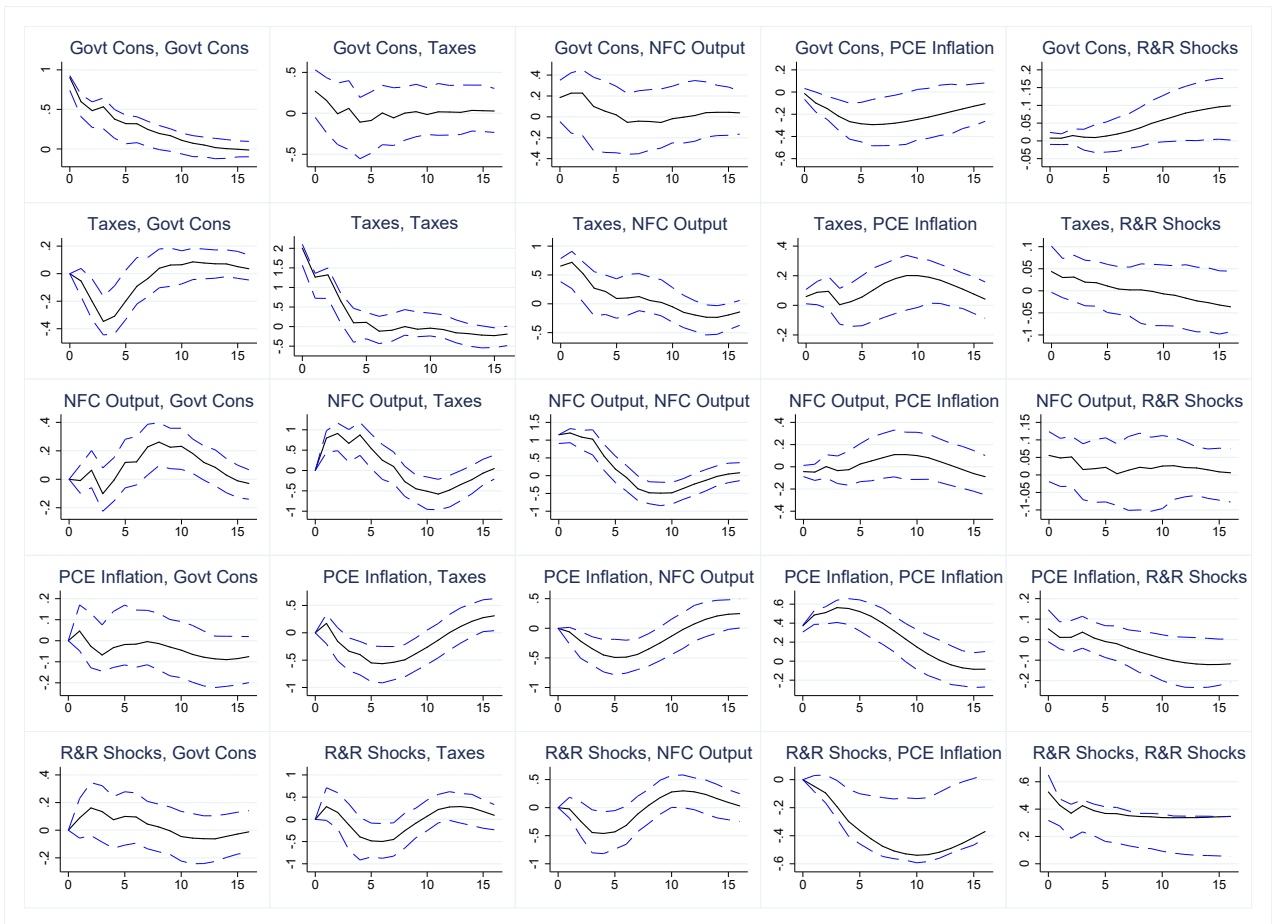
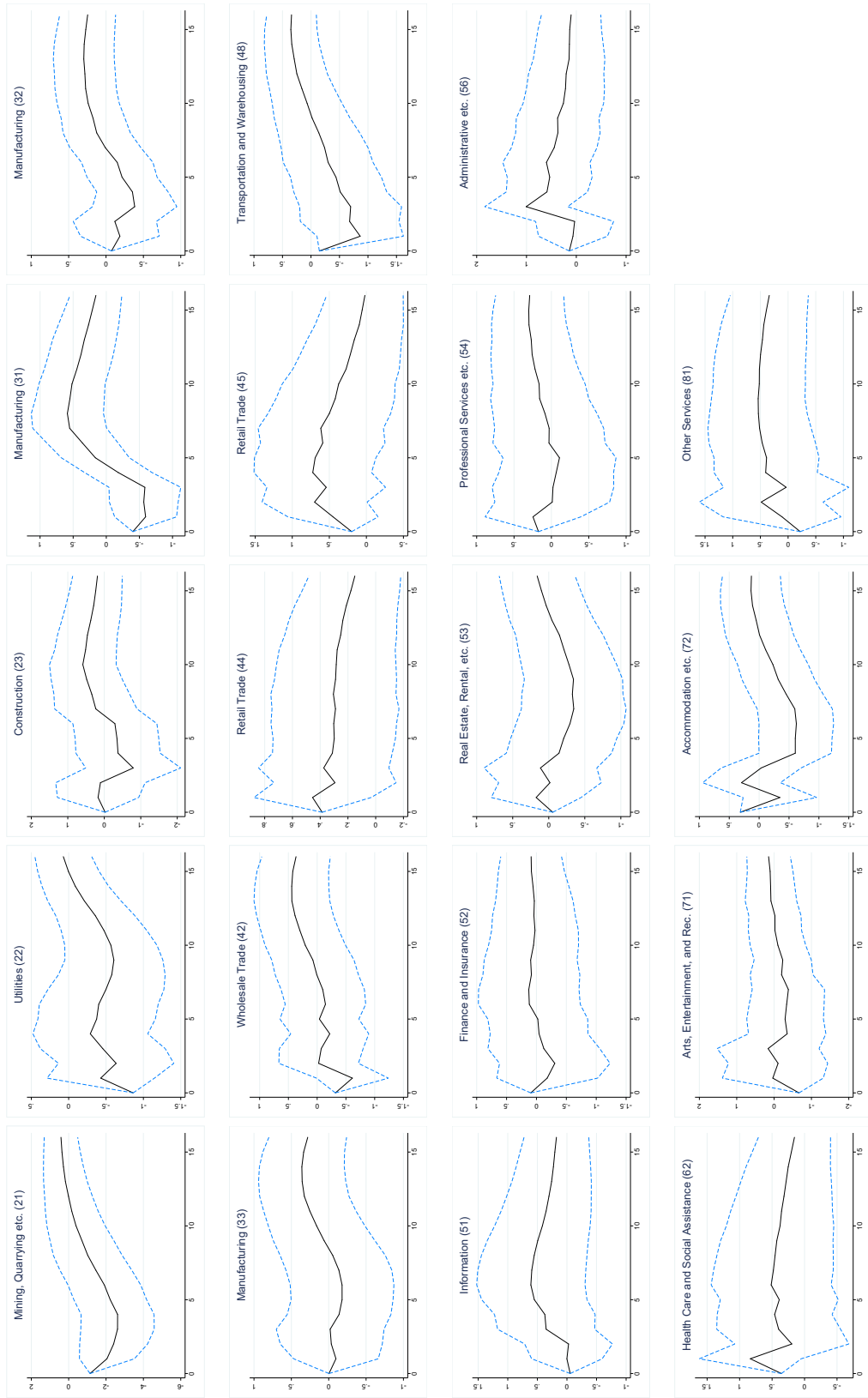


Figure 6: Industry orthogonalized responses to one standard deviation government spending shock, 1971:Q1-2008:Q3. The x-axes denote quarters. Asymptotic 90% confidence intervals outlined in blue.



References

- Barth, M. J. and Ramey, V. A. (2002). The Cost Channel of Monetary Transmission. In *NBER Macroeconomics Annual 2001, Volume 16*, NBER Chapters, pages 199–256. National Bureau of Economic Research, Inc.
- Friedman, B. M. (1986). Money, credit, and interest rates in the business cycle. In *The American business cycle: Continuity and change*, pages 395–458. University of Chicago Press.
- Ilzetzki, E. (2011). Fiscal policy and debt dynamics in developing countries. *World Bank Policy Research Working Paper Series, Vol.*
- Romer, C. D. and Romer, D. H. (1989). Does monetary policy matter? a new test in the spirit of friedman and schwartz. In *NBER Macroeconomics Annual 1989, Volume 4*, pages 121–184. MIT Press.