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ESSAYS IN MONETARY ECONOMICS

A dissertation submitted in partial satisfaction of the
requirements for the degree of

DOCTOR OF PHILOSOPHY

in

ECONOMICS

by

Arsenios Skaperdas

June 2016

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Abstract

Essays in Monetary Economics

by

Arsenios Skaperdas

This dissertation focuses broadly on central bank intervention: under what conditions, and when, can stabilization policy be effective? As growth lags across the globe, central banks have become lead actors in spurring recovery from the Global Financial Crisis. In response, a large academic literature has developed in order to theoretically predict and measure to what extent central bank policies have succeeded in stimulating growth.

The first two chapters of this dissertation focus on US monetary policy. I develop two new approaches for investigating the effectiveness of monetary policy at the zero lower bound, that is, when interest rates are near zero. A novelty of these approaches is the usage of firm- and industry-level data in order to investigate effects of monetary policy.

The zero bound on interest rates is the problem that- given low growth since 2008- the Federal Reserve would likely have lowered the federal funds rate further in to maximize employment and increase inflation. Previous behavior suggests that the Fed would have reduced the federal funds rate to a trough of 5 percentage points below zero. According to accepted empirics [Coibion, 2012], a contractionary 5% monetary shock should lower GDP growth by a peak of 2.5%.

This dissertation leverages the fact that the industry effects of detrimental monetary policy would be heterogeneous: a substantial portion of this reduction in growth would occur in industries such as construction, which typically would respond with a 10% reduction in revenues to a 5% contractionary monetary shock. In contrast, health care and other industries do not tend to respond as much to interest rates changes, and would thus likely be unaffected

The first approach of this dissertation shows that growth rates of industries historically sensitive to interest rate changes, and therefore to monetary policy, do not seem to have fared poorly at the zero lower bound. This suggests that monetary policy was sufficiently accommodative since 2009 in spite of the zero bound constraint.

The second approach quantifies the federal funds rate that would be implied by observed industry growth rates and macroeconomic variables following 2008. The results suggest that unconventional policy had an effect on the economy such that growth occurred as if the federal funds rate were in fact negative. Unlike previous literature, this estimate is based on growth rates of real rather than financial market variables. The technique extracts the path of the federal funds rate at the zero lower bound consistent with pre-zero lower bound macroeconomic dynamics. Given the negative interest rate estimate from this second approach, and the relative growth rates of interest rate sensitive industries, the first two chapters suggest that the combination of zero interest rates and unconventional policy succeeded in spurring economic growth in a comparable fashion to previous US recoveries.

The third chapter of this dissertation focuses on an international aspect of

central banking. Due to a combination of desires for precautionary savings and exchange rate undervaluation, central banks often accumulate reserves. This chapter examines the relationship between foreign reserve accumulation and domestic investment. A central bank's purchases of reserves implies an outflow of domestic savings. If capital markets are imperfect, foreign capital cannot be expected to compensate for this savings outflow. The third chapter thus measures to what extent reserve accumulation is correlated with decreases in domestic investment. In contrast to [Reinhart et al., 2016], I find that reserve accumulation does not seem to hamper domestic investment. I conclude with a brief discussion of other possible explanations for the finding and directions for future research.

The layout of this dissertation differs slightly from that of the three separate chapters. The first chapter presents the two approaches created for measuring monetary policy at the zero bound. The second chapter expands upon these two approaches, and shows that the findings are highly robust to specification choices, and unlikely to be caused by alternative explanations. Finally, the third chapter presents the portion of this dissertation examining open economy central bank interventions.

Acknowledgments

I am very thankful to my advisors, Michael Hutchison and Carl Walsh, for invaluable guidance throughout my PhD. My committee members, Kenneth Kletzer and David Draper, were very helpful and especially generous with their time. I am also grateful to Johanna Francis for continued feedback and crucial encouragement at an early stage while she was a Visiting Professor at UC Santa Cruz.

I thank my fellow PhD students for important advice and growth through my time at Santa Cruz, and especially Benjamin Garcia, Chris Limnios, and Evan Smith for an untold number of discussions about research.

I am grateful to the Monetary Policy Division and other employees at the Central Bank of Ireland, including Peter Dunne and Rebecca Stuart. During a six month internship supported by the Bank, I made significant progress on my job market paper, gained important work experience, and had great opportunities to present and discuss research with colleagues.

Finally, I am extremely grateful to my parents, Stergios and Marina, and my sister, Eleni. Without their support it would not have been possible to finish this dissertation.

Chapter 1

How effective is Monetary Policy at the zero lower bound? Identification through industry heterogeneity

1.1 Introduction

The key indicator of US monetary policy, the federal funds rate, has been set to near zero since December 2008. Ordinarily, the Federal Reserve would have lowered this rate significantly further into negative territory in order to increase economic growth and fulfill its mandate of stable prices and maximum employment [Rudebusch, 2009]. Given the Federal Reserve's previous behavior, and conventional wisdom of the role of monetary policy, the inability to further decrease the federal funds rate should have had

a peak effect on GDP growth ranging from -1 to -2.5%.[1]

In order to counteract the zero bound constraint, the Fed has carried out a series of unconventional policy actions. Since 2008, the Fed has greatly expanded its balance sheet, and accumulated $4.5 trillion in assets. However, standard theory predicts that unconventional policy should have had little effect [Walsh, 2014, Woodford, 2012].

Due to the lack of historical experience with near zero interest rates, researchers face a challenging time in characterizing the effectiveness of policy since 2008. Common tools such as vector autoregressions cannot be directly used, as no single measure of monetary policy exists encapsulating the extent of the unprecedented actions taken by the Federal Reserve. Developing new methods to assess monetary policy is thus an important priority for policymakers.

In this chapter, I develop two new approaches to shed light on the effectiveness of monetary policy at the zero lower bound using industry data. I first bypass the difficulty in assessing monetary shocks by investigating whether policy has had similar heterogeneous industry effects as in unconstrained periods. If monetary policy has been constrained, and aggregate growth has been negatively affected, it must also be the case that industry growth rates have been affected. However, industry growth rates would not all be affected in the same way.

I ask the following question: have sectors differentially affected by monetary policy in previous recoveries had similar differential effects since 2009? If the zero lower bound has been a binding constraint on monetary policy, we should expect to see that

[1]This is assuming a desired negative rate ranging from -2 to -5%, and standard empirics of the effects of federal funds rate changes on GDP growth [Coibion, 2012].

interest rate sensitive industries have differentially less revenue growth than insensitive industries, since 2009, in comparison to previous recoveries. This would be the case if revenue growth in interest rate sensitive industries was hurt by the inability of the Federal Reserve to further lower the federal funds rate, and if unconventional policy failed to bridge this "monetary shortfall" [Rudebusch, 2009].

In contrast, I surprisingly find that industries that have historically been more interest rate sensitive, such as construction, have differentially greater revenue growth rates than insensitive industries, such as health care and social assistance. In particular, estimates from the pre-zero bound period imply that a 5% monetary contraction, equivalent to a standard estimate of the Fed's inability to lower the federal funds rate to its desired negative value [Rudebusch, 2009], should have caused a decrease in construction revenues of roughly 10% relative to health care and social assistance. I find no evidence that this type of relationship holds across industries. Furthermore, the revenue growth differential during the zero lower bound period is equal or greater than benchmark differential growth rates observed during previous unconstrained economic recoveries. More broadly, when examining longer-term trends, the growth of interest rate sensitive industries is in accordance with historical norms.

I then quantify to what extent the results are due to unconventional monetary policy. I develop an approach that departs from current literature [Krippner, 2013, Wu and Xia, 2014, Lombardi and Zhu, 2014, Christensen et al., 2013] by directly inferring the implied effective federal funds rate from observed industry growth rates and standard variables used in monetary vector autoregression models, rather than financial

market variables.

I extract the path of the federal funds rate at the zero lower bound consistent with pre-zero lower bound macroeconomic dynamics. While controlling for the effects of fiscal policy, which are significant, I find evidence that the implied monetary policy rate is negative for part of the zero bound period.[2] This helps to explain why it does not seem that interest rate sensitive industries have been detrimentally affected by monetary policy.

Overall, the findings in this chapter 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 negative interest rate estimate from the second approach, and the relative growth rates of interest rate sensitive industries in the first approach, I infer suggestive evidence that the combination of zero interest rates and unconventional policy succeeded in spurring economic growth in a comparable fashion to previous US recoveries.

The layout of the paper is as follows: Section 1.2 establishes how this chapter relates to the literature on the zero lower bound. Section 1.3 discusses assumptions of the paper necessary for identification. Sections 1.4, 1.5, 1.6, and 2.1 explain the data, methodology, results, and robustness of the first approach. Section 2.2 discusses alternative explanations for the results from the first approach. Section 1.7 presents the second approach, which explores whether the results are attributable to unconventional monetary policy. Finally, Section 1.8 concludes.

[2]The finding that fiscal policy is an important omitted variable is compatible with the existence of non-linear fiscal multipliers at the zero bound [Christiano et al., 2011, Woodford, 2011].

1.2 Related Literature

The identification strategies of this chapter 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, 1994a] 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 chapter 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 chapter'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. While useful, these estimates are dependent on model assumptions, including which yields are used. The estimates of

[Krippner, 2013] range to -9%, while [Wu and Xia, 2014] find that their shadow rate troughs above -4%. In addition, these papers attempt to measure the interest rate as implied by financial markets. In contrast, Section 1.7 estimates the effective federal funds rate as implied by real macroeconomic variables and industry growth rates.

A second approach to calculating a shadow short rate is pioneered by [Lombardi and Zhu, 2014]. These authors use a dynamic factor model calibrated from before the crisis based on interest rates, the Fed's balance sheet, and monetary aggregates. The model performs realistically in sample, and also implies negative interest rates at time after 2008. In order for their measure to be comparable to the federal funds rate before the crisis, one must assume that balance sheet increases and changes in monetary aggregates cause similar real and financial effects after hitting the zero lower bound.

[Swanson and Williams, 2014] pursue a different avenue to examine whether the zero lower bound has constrained monetary policy. The authors analyze the responsiveness of one and two year Treasury yields to news, finding that they were unconstrained prior to late 2011. This implies that policy had leeway in setting interest rates, meaning that the ZLB was not too binding. The results found in this chapter are qualitatively consistent with [Krippner, 2013], [Wu and Xia, 2014], [Lombardi and Zhu, 2014] and [Swanson and Williams, 2014], in that they suggest monetary policy was not heavily constrained by the zero lower bound.

A large literature has examined the financial responses of unconventional policy, mostly focusing on the effects of large scale asset purchases of US long term Trea-

sury Bonds and mortgage-backed securities. Research has examined two channels of policy actions: that of actual Federal Reserve purchases and the effects of important policy announcements. Thus far, researchers have found significant effects of announcements on Treasury Bills and the yield curve [Gagnon et al., 2011], exchange rates [Glick and Leduc, 2012, Glick and Leduc, 2013], capital flows [Fratzscher et al., 2012], corporate bond yields [Krishnamurthy and Vissing-Jorgensen, 2011], and tail risk perceptions [Hattori et al., 2013]. In general, this literature has found that unconventional policy has had largely similar effects to conventional policy.

Recent research [Gambacorta et al., 2014] using panel VAR techniques on monthly asset purchases has also come to the conclusion that unconventional policy has been effective. However, more research on the real effects of monetary policy at the zero lower bound is needed. Additionally, measures of unconventional policy effectiveness do not place the overall effectiveness of monetary policy at the zero lower bound into context with policy effectiveness during normal times.

Dynamic stochastic general equilibrium modeling has also been used to gain insight into the zero lower bound environment. [Fratto and Uhlig, 2014] adapt the model of [Smets and Wouters, 2003] to account for inflation rates since 2007. Using the estimated model and shock decomposition, the authors find that the the 2008-2010 period was characterized by a negative output gap, in part accounted for by a sequence of mild positive interest rate shocks as the economy hit the zero lower bound. However, they also find monetary policy was actually more accommodative than that predicted by a Taylor rule following 2010. Thus, the authors' result that the ZLB was only mildly

constraining is in accordance with the literature using yield curves.

In other relevant DSGE research, [Erceg and Levin, 2006] show using a VAR that the durable goods sectors are much more interest-sensitive than nondurables. The authors calibrate a DSGE model to match the sectoral responses of the VAR, and find that a simple rule targeting a weighted average of aggregate wage and price inflation performs better than a rule stabilizing a narrow measure of final goods production. this chapter builds upon the insight of [Erceg and Levin, 2006] regarding how sectoral responses play an important role in the effects of monetary policy. I follow their approach in using a VAR to calculate sectoral responses, but go a step further in the categorization of a large number of industries.

An alternative approach to DSGE modelling, involving a large scale model, is that of [Engen et al., 2015]. The authors use the Federal Reserve's FRB/US model to simluate the effect of changes in private-sector perceptions of the Federal Reserve's policy rule. The authors find that the unemployment effect of 1.25 percentage points peaks in 2015.

Finally, this chapter follows [Claessens et al., 2011] and [Laeven and Valencia, 2013] in the usage 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 chapter 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 chapter has begun from the premise that interest rate decreases have non-negligible effects on output. If this is not the case, this chapter's results provide no meaningful evidence that monetary policy is effective at the zero lower bound.[3] Nonetheless, 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.

1.3 Identification

The magnitude of monetary shocks since 2008 is an unobserved variable. This makes it necessary to make assumptions about how this unobserved variable relates to observed variables during the zero lower bound period.

In the first approach of this chapter, I create an interest rate sensitivity index, then use it to predict how sectors should grow differentially during economic recoveries. I thus assume that the structural responses of industries to monetary policy have a time-invariant component. Furthermore, I must rule out omitted variables that could bias the relationship between industrial interest rate sensitivity and revenue growth at the zero lower bound. Formally, consider the following general relationship:

$$g_{i,j,t-k,t} = f(\psi_{t-k,t} \cdot \phi_j, X_{1i,t}, X_{2j,t}, U_{1i,t}, U_{2j,t}, \epsilon_{i,t-k,t}) \tag{1.1}$$

[3] In fact, examining monetary shocks using all contemporary methods, [Ramey, 2015] finds there is still uncertainty over how strong the effects of interest rate changes actually are.

where $g_{i,j,t-k,t}$ is firm $i's$ real revenue growth between periods $t-k$ and t in industry j. Revenue growth is a function of ϕ_j, an index of industry $j's$ time invariant sensitivity to monetary policy, interacted with the magnitude of the monetary policy shock, $\psi_{t-k,t}$. $X_{1i,t}$ and $X_{j2,t}$ are vectors of observable variables, and $U_{1i,t}$ and $U_{2j,t}$ vectors of unobservables, varying at the firm and industry levels respectively. Finally, $\epsilon_{i,t-k,t}$ is an idiosyncratic error term.

I construct ϕ_j, and examine growth in the recoveries following 1991, 2001, and 2009. I create an index that isolates plausibly exogenous industry responses to monetary policy, to be described later. I then assume a functional form of (1.1), and argue that I capture coefficients on the industry index measuring that should provide evidence of large monetary movements. However, the primary purpose of this approach is to examine whether the magnitude and significance of the coefficient on ϕ_j, capturing monetary policy sensitivity, is different in the current recovery. This coefficient $\psi_{t-k,t}$ is interesting because it indirectly sheds light on the magnitude of the monetary shock.

I find that the coefficient $\psi_{t-k,t}$ during the zero lower bound period is not statistically differentiable from the measured coefficient during economic recoveries unconstrained by the zero bound. In order for this to be the case in spite of a decrease in monetary policy effectiveness, unobservable variables would need to exist in magnitude that are positively correlated with interest sensitivity since 2009 relative to previous recoveries. Formally, the identified result that monetary policy has been as effective at the zero lower bound in comparison to previous recoveries relies on the assumption that the net effect of the correlations of each omitted variable in the vector U,

$Corr(u_{2,j,2009}, \phi_j) \leq Corr(u_{2,j,t}, \phi_j)$, for $t \neq 2009$. In the second chapter, I emphasize the validity of this assumption by ruling out other shocks that could bias the results.

In the second approach of the paper, I evaluate the monetary stance by identifying the effective federal funds rate as measured by realized economic variables. This method assumes that the structural interrelationships between output, inflation, and the federal funds rate are stable from 1988:Q1 to 2014:Q2, the last date for which data is observed. In addition, the method assumes that industry revenues are characterized by similar dynamic relationships with macroeconomic aggregates, in addition to the effective federal funds rate, during the zero lower bound period. I discuss further details of these assumptions in Section 1.7.

1.4 Data

1.4.1 Data

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. It is not clear how this generalizes to non-Compustat firms. On the one hand, publicly-held firms are much larger, and as such are thought to be less affected by monetary policy. On the other hand, it may be the case that programs such as quantitative easing disproportionately benefit public firms through increases in stock and bond valuation.

For index construction, I use the Compustat Quarterly North America

database in the time period 1970:Q1-2008:Q3. This time sample is chosen such that it precedes the crisis period and the incidence of the recovery at zero lower bound.

For the difference-in-difference regressions and firm-level balance sheet information, I use the annual Compustat dataset for the respective years examined. All US macro data is from FRED. Finally, fiscal variables are taken from the Bureau of Economic Analysis.

1.4.2 Industry Time Series Construction

To my knowledge, no consistent time series of industry growth exists.[4] I thus construct a 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 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). Figure 1.1 plots mean revenues for selected industries over the sample period, showing that mean industry revenues do not follow any clear growth trend. I thus examine growth rates of revenues[5] rather than aggregate or averages.

I follow the micro employment literature [Davis et al., 1998] in specifying firm-

[4]The 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.

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

level growth rates as

$$g_{i,t-k,t} = \frac{y_{i,t} - y_{i,t-k}}{0.5[y_{i,t} + y_{i,t-k}]} \tag{1.2}$$

Where $y_{i,t}$ is the variable of interest of firm i 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, and corrects for the effects of outliers.

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 (1.2)

$$g_{j,t} = \frac{1}{n_{j,t}} \sum_{i=1}^{n_{j,t}} g_{i,t-4,t} \tag{1.3}$$

Where $n_{j,t}$ is the number of firms in industry j at time t with year-over-year revenue statistics. Figure 1.4 charts the growth rates resulting from this process.

1.5 Methodology

This section discusses the methodology of the first approach I use to evaluate monetary policy. The method involves to 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

of the two steps, while Section 1.6 presents the results from the two steps.

1.5.1 Industry Interest Rate Sensitivity Index Construction

The interest rate sensitivity index is created using structural impulse responses from industry-level 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. [6] I use the SVARs to measure to what extent an unpredictable interest rate increase is associated with future decreases in revenues for each industry. I interpret this as a causal relationship. In support of this, I use an alternate measure of monetary shocks in Section 2.1, and find a very similar industry ranking of interest rate sensitivity. The ranking is highly correlated across SVAR lag lengths, recursive orderings, and a variety of other specification choices.

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

$$B_0 Y_t = C + B_1 Y_{t-1} + u_t \tag{1.4}$$

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

[6] An 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].

lagged parameters such that industries do not affect any of the macroeconomic variables.[7] Empirically, quarterly corporate industry revenues are a relatively small portion of gross revenues (see Figure 1.2), justifying this structure.

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 revenues growth, commodity price inflation,[8] personal consumption expenditures inflation,[9] and the federal funds rate.[10] 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 the time series of industry revenues. A lag length of 4 is chosen as suggested by the AIC, and as is common in the monetary VAR literature.

Figure 1.3 graphs the number of quarterly firm observations by industry in the sample. As is apparent in the graph, industries 11, 49, and 61 have significantly fewer

[7] Thus, the parameters characterizing macroeconomic aggregates are by construction equal to the parameters resulting from a standard recursive VAR.

[8] Series PPIACO from FRED.

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

[10] The identification scheme used is standard in the literature for VARs analyzing monetary policy with quarterly data [Christiano et al., 1999].

firms per quarter.[11] Since these industries each have such a small number of firms, VAR results using industry aggregates will be more uncertain due to the larger effects of idiosyncratic firm-level shocks. The noisiness of those three industries is apparent in Figure 1.4. The series for these industries are characterized by much higher variability than the other industries, and Education (61) in particular has large spikes in growth rates. Likewise, Table 1.1 shows that (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" difference-in-difference analysis.[12]

I quantify the SVAR revenue effects of monetary policy by recording the minimum point estimate[13] of the orthogonalized industry revenue response over four years to a positive one standard deviation interest rate shock from each SVAR in equation (1.4). 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 the difference-in-difference regressions, 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

[11] These industries are Agriculture, Forestry, Fishing and Hunting (11), Transportation and Warehousing (49), and Educational Services (61).

[12] In the second chapter, I show that including these industries does not change any of the results

[13] Industries with positive responses to monetary shocks are thus set to zero before standardization. Alternative specifications of the index are discussed in Section 2.1.

increase in the index thus signifies a one standard deviation increase in interest rate sensitivity.

Formally, let $\chi_j = \min_{i=0}^{16} \left(\frac{\partial g_{j,i}}{\partial u_{5t}} \right)$, where $g_{j,i}$ is the revenue growth rate at quarterly horizon i 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

$$\phi_j = -1 \cdot \left(\frac{\chi_j - \bar{\chi_j}}{\sigma} \right) \tag{1.5}$$

where σ denotes the standard deviation of χ_j.

The literature on monetary policy has noted that 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 chapter, I examine the symmetric case, as is the case in the majority of the VAR literature.

1.5.2 Second-Stage Difference-In-Difference

I use the standardized sensitivity index to predict real revenue growth, as defined in equation (1.2), in the following differences-in-differences specification:

$$g_{i,j,t-k,t} = \psi \cdot (\phi_j I_{2009,2012}) + \delta\phi_j + \gamma_{t-k,t} I_{t-k,t} + \beta X_{i,j,t-k,t} \cdot I_{t-k,t} + \epsilon_{i,j,t-k,t} \tag{1.6}$$

Where $g_{i,j,t-k,t}$ is the 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, 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.[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]. It is important to note that the first two recoveries are during the time sample in which the VAR models are estimated, while 2009-2012 growth is an out-of-sample prediction of the index based on the VAR impulse responses.

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 1.2 presents summary statistics on relevant firm variables used in this chapter. It is of interest to note that the 2009-2012 recovery is not characterized by

[14]The 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, as shown in the second chapter.

[15]Note 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.

lower revenues or employment growth than previous recoveries. In fact, the 2009-2012 period has greater employment and revenues growth than the 2001-2004 recovery.

1.6 Empirical Results

1.6.1 SVAR Index Results

I first investigate the industry interest rate sensitivity classification. Figure 1.5 graphs the orthogonalized industry impulse responses to an interest rate shock upon which the standardized index is created.[16] Table 1.3 presents the minimum response values to a one standard deviation shock, along with the standardized reciprocal explained previously. The ordering of industries aligns with common priors. Broadly speaking, the more interest rate sensitive industries are more capital intensive, and produce goods of greater durability.

According to the responses, Construction (23)[17] and Mining, Quarrying, and Oil and Gas Extraction (21)[18] 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 commonly found in the

[16]In 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. The SVAR models are estimated over the artificial time series, yielding distributions 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.

[17]Evidence from the Bureau of Economic Anaylsis 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].

[18]The 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.

literature [Erceg and Levin, 2006].

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 significantly different from each other. In addition, it is possible that exchange rate changes following interest rate changes mitigate the net effect on retail.

The finding that utilities are somewhat affected by interest rates may be counterintuitive. In fact, utility companies have high debt loads,[19] and many utility companies are subject to regulation which can cause decreases in their ability to adjust to interest rate changes.

Before moving on to the aggregate responses, one aspect of the industry responses in Figure 1.5 merits attention. Although the impulse responses could appear smoother, they still very much contain information. in the second chapter, I chart the impulse responses with only two lags. With this lag length specification, the impulse

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

responses are cleaner, while the industry ordering remains largely unchanged.

Aggregate responses of the VAR are presented in Figure 1.6, showing that the VAR has impulse responses typically found in the literature. A demand (real gdp) shock results in the monetary authority increasing the federal funds rate. A commodity price shock results in a small increase in the federal funds rate, increases in prices, and a decrease in gdp. Finally, an interest rate shock decreases real gdp.[20]

1.6.2 Second Stage Difference-in-Difference

Correlations

Before examining more robust econometric estimates, it is worth examining the data in a simple graphical manner. Figure 1.7 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.[21] This traces out 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 chapter. If the zero lower bound has constrained monetary policy, we should see that interest rate sensitive industries have been detrimentally affected.

[20]The 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]. Possible empirical solutions include adding a commodity price index to the VAR as a forward-looking price variable or exchanging real gdp with an output gap measure. These changes fail to cause a decrease in the price level due to a monetary shock in the sample examined. In a meta-analysis, [Rusnák et al., 2013] find that the only consistent way to solve the price puzzle is to use VARs with sign restrictions. Although the price puzzle is present in the sample used in this chapter, it is of note that all other impulse responses are of the anticipated sign.

[21]The figure charts the equivalent of the coefficient estimates on interest rate sensitivity (ϕ_j) in an OLS regression over each three year window ($g_{j,t-k,t} = \alpha + \beta\phi_j + \epsilon_{j,t-k,t}$) of revenue growth. Two year industry growth rates result in similar dynamics.

This is not the case. In Section 1.7, I find that this is likely due in part to unconventional monetary policy.

Another interesting aspect of Figure 1.7 is that the pre-crisis years in the 2000s are characterized by large increases in revenues of interest rate sensitive industries. Numerous researchers have claimed that by keeping interest rates too low for too long, the Federal Reserve contributed to the unsustainable buildup in housing, and its effects on the aggregate economy [Taylor, 2007, Jarocinski and Smets, 2008, Ahrend, 2010]. The finding that interest rate sensitive industries, such as construction, grew abnormally fast in the buildup to the crisis is also consistent with a vast literature examining the effects of the housing bubble [Mian and Sufi, 2009]. Figure 1.7 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.

Figure 1.7 does not exhibit great variation through time, while it perhaps could reflect federal funds rate movements more concretely. However, it is not clear that we should expect to see large fluctuations in differential industry revenue growth rates due to monetary policy in normal times with three year growth rates, which do smooth out short term variation. The important aspect of Figure 1.7 to take away is that the post-crisis period does not seem to be characterized by a monetary contraction relative to trend.[22]

As a second exercise, I graph scatter plots of industry revenue growth rates

[22]Note also that a time trend in interest rate sensitive industries would not make sense, in that it would imply that those industries should increasingly become a larger portion of the economy.

and interest rate sensitivity in Figure 1.8. 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 has a similar industry response to the post-2009 period.[23] 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 1.4 presents the basic test of this chapter, estimating equation (1.6) at the firm-level. Firm-level data is useful, as it will allow firm-level controls.[24] The coefficient on the index interacted with 2009-2012 reveals that a one standard deviation increase in industry sensitivity is associated with similar increases in relative revenues over that period in comparison to previous recoveries. The index coefficient not interacted with 2009-2012 is not significantly different from zero, as it is a combination of the 2001-2004 recovery, which is characterized by negative growth, and 2001-2004, which is characterized by positive growth.

The fact that the interaction of the index and the 2009-2012 recovery is no less

[23]These regressions are available in the second chapter.

[24]Note that industry- and firm- level data give similar results, but that firm-level data allows richer controls.

than previous recoveries is a major finding of this chapter. Firms in industries typically sensitive to monetary policy have not had diminished revenue growth in the current recovery, providing evidence that those industries have no 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. This is evidence that the VAR impulse responses are managing to identify effects of unsystematic 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 difference-in-difference specification (1.4). 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 revenues growth due to financing friction differences between small and large firms, as documented by [Gertler and Gilchrist, 1994a] 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 revenues 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 grow 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 difference-in-difference regressions. In all cases, this secular growth measure does not affect the results in any way, implying that secular trends are not driving the result of monetary policy effectiveness.[25]

Although column (4) of Table 1.4 controls for secular industry trends over the

[25]This 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. In practice, interacting the trend coefficient with each recovery indicator only increases the relative growth of interest rate sensitive industries at the zero bound. Finally, controlling for industry growth rate time trends also yields similar results.

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 1.6 estimates equation (1.6), using the time periods preceding the recoveries (1988-1991, 1998-2001, and 2006-2009). The index coefficients are meaning that there were industry pre-trends correlated with interest rate sensitivity. However, the 2006-2009 coefficient estimate is not statistically significant.[26]

It is worrying that the index coefficients are significantly negative in Table 1.6, 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.[27]

In order to control for this potential mean reversion, I use three year lagged growth rates as control variables.[28] Table 1.7 presents the results, showing that the index coefficients from 2009-2012 are unchanged from Table 1.4, meaning that mean

[26]Note that a negative coefficient for the 1988-1991 period corroborates [Walsh, 1993], who finds that the buildup to the 1990 recession was due to restrictive monetary policy.

[27][Martin 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.

[28]Specifically, I include the growth rates from 1988-1991, 1998-2001, and 2006-2009 interacted with the recovery indicators in equation (1.6).

reversion cannot account for the growth in industries sensitive to monetary policy.[29]

1.7 Identifying the Policy Stance

1.7.1 Methodology

Thus far, evidence on monetary policy effectiveness has been presented through an inferential approach comparing recoveries. However, previous recoveries may differ from the counter-factual of the post-2008 period, as it is still possible that firms could have grown differently without the zero lower bound. Formally, as discussed in Section 1.3, equation (1.1) may suffer from omitted variables, meaning that $g_{i,j,t-k,t}$ may not reflect the magnitude of $\xi_{t-k,t}$.

In this section, I evaluate how much the results are attributable to monetary policy. I find tentative evidence that unconventional policy succeeded in stimulating growth in excess of what a federal funds rate of zero would suggest. I infer the implied federal funds rate based on the growth rates of industry revenues, and macroeconomic aggregates used throughout the paper.

I use the Kalman filter to extract a measure of the implied federal funds rate, $\xi_{t-k,t}$, on a quarterly basis. Specifically, I use the structural forms of the models in

[29] Using 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. However, I believe this is preferable to using lagged dependent variables as instruments.

(1.4). For expositional purposes, consider a bivariate VAR(1) system in structural form

$$B_0 Y_t = B_1 Y_{t-1} + u_t \tag{1.7}$$

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

$$x_t = B_1(1,1)x_{t-1} + B_1(1,2)z_{t-1} + u_{1t} \tag{1.8}$$

$$z_t = -B_0(2,1)x_t + B_1(2,2)x_{t-1} + B_1(2,1)z_{t-1} + u_{2t}$$

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, (1.8) 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:

$$x_t = \underbrace{\hat{B}_0(1,1)x_{t-1}}_{\text{deterministic}} + (\hat{B}_1)(1,2)z_{t-1} + u_{1t} \tag{1.9}$$

while the state equation is defined as:

$$z_t = \underbrace{-\hat{B}_0(2,1)x_t + (\hat{B}_1)(2,2)x_{t-1}}_{\text{deterministic}} + \hat{B}_1(2,1)z_{t-1} + u_{2t} \tag{1.10}$$

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 residuals of structural forecasts[30] of the SVAR equations into an interest rate component and other disturbances. Thus, it measures the extent to which the federal funds rate deviates from the VAR prediction of the endogenous Federal Reserve reaction function.

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

$$Z_t = \hat{c} + \hat{B}(L)W_t + \hat{\Gamma}(L)Z_{t-1} + u_{5t} \tag{1.11}$$

$$X_t = \hat{C} + \hat{F}(L)W_t + \hat{\Lambda}(L)Z_{t-1} + \zeta_t \tag{1.12}$$

where Z_t, the state, is the federal funds rate during quarter t, and X_t is a vector of the variables used in the VARs: each quarter's GDP growth, commodity price growth, PCE growth, and revenue growth for each industry.[31] The vector W_t is equal to the vector of macroeconomic observation variables, and does not include industry revenues. The

[30]Note that, like any statistical model following the financial crisis, VARs have poor forecast accuracy during the Great Recession due to a sequence of effective negative demand shocks. However, the Kalman filter in theory should be able to statistically differentiate between contemporaneous GDP growth shocks and monetary policy shocks.

[31]Note 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.

error term u_{5t} and the vector of errors ζ_t are normally distributed. The vector C and c are the constants from the right hand side variables of each line in the system.

I make one change to the SVARs from Section 1.4.2. In order to to estimate an implied measure of the federal funds rate at the zero lower bound, I need the Federal Reserve's reaction function to be stable, and to adequately capture Fed decision making. [Rudebusch, 2009] uses the 1988-2008 period to show that the policy rate is well captured during that time period by a simple Taylor rule, and traces out the monetary shortfall at the zero lower bound; that is, the implied target rate consistent with Fed behavior. I thus follow [Rudebusch, 2009] in using this subsample for SVAR estimation.

The SVARs are run, yielding structural forms for the federal funds rate, macro variables, and industry revenues. As explained, I then input the parameters and data from both the 1988Q1-2008:Q3 and zero lower bound period into equations (1.11) and (2.2), treating $\hat{B}(L)W_t$ as an exogenous disturbance term to the state equation. I do a similar computation for $\hat{F}(L)W_t$ in the measurement equations. Finally, I run the Kalman filter on this system, treating Z_t as the unobserved state.[32]

A few important aspects of the estimated state series Z_t are worth mentioning. First, I wish to emphasize that it is not meant to 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 the estimate of the federal funds rate that would imply the realizations of X_t observed post-zero lower bound. Thus, Z_t reveals the implied federal funds rate based on realized outcomes of macro variables and industry aggregates.

[32]Further details can be found in the second chapter.

However, this estimate is conditional on the 1988:Q1-2008:Q3 VAR pre-zero lower bound dynamics. If the entire structure of the economy has changed- that is, 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:Q3. This implies that the 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 federal funds rate likely understates the true effective federal funds rate 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.

1.7.2 Results

Figure 1.7 plots the filtered state equation from equations (1.11) and (2.2). As shown in the figure, the estimate is negative until 2012.[33] Taken at face value,

[33]In order to get a sense of the importance of the uncertainty associated with the SVAR parameter estimates, I chart standard errors corrected for generated regressors in the second chapter. I run the Kalman filter on a distribution of 200 sets of industry SVARs, simulated from artificial time series as explained in Footnote 16. Accounting for the generated VAR parameters does not significantly increase

this implies that unconventional policy was able to stimulate corporate industries in excess of a federal funds rate of zero. However, Figure 1.7 also plots the predicted SVAR federal funds rate with no shocks to the interest rate equation, showing that the negative interest rate result is likely driven by the Federal Reserve's reaction function.

Figure 1.11 charts the impulse responses from the underlying macro VAR used in the state-space system.[34] As shown in the figure, GDP growth has a statistically indeterminate response to output, and actually is positive in the first few quarters. This makes it difficult for the Kalman filter to isolate the effects of interest rate changes on the measurement equations. The small aggregate GDP response means that the Kalman filter has less power to decompose the VAR one step ahead forecast residuals into an interest rate disturbance and other exogenous factors.[35]

It is thus important to examine alternative VARs where the GDP response to interest rate shocks is positive, so as to accurately measure deviations from the endogenous federal funds rate forecast. Two reasons have 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

the uncertainty associated with the state estimate.

[34]Recall that by construction, the underlying macro variables have the same dynamics in the SVARs run for each industry, and that the macro variable parameters in each industry SVAR are equivalent to the parameters in a recursively identified VAR with no industry growth rates.

[35]Using the industry growth rate series is also important. With an increased number of measurement equations, the Kalman filter has more information upon which to base an estimate of the state. Each measurement equation is optimally weighted by its variance, meaning that a larger number of measurement equations decreases the variance of the state. This is similar in concept to the added efficiency of GMM (general method of moments) when using instrumental variables. With multiple instruments, the GMM framework allows each instrument to be optimally weighted by its variance. A larger number of instruments increases precision. In practice, the industry growth equations are important for the Kalman filter to converge in some specifications.

interest rate movements are more systematic and endogenous than in earlier periods, VARs are unable to identify the effects of unsystematic interest rate shocks. This explains why the state estimate is almost identical to the prediction of the VAR with no structural shocks to the federal funds rate equation. The Kalman filter is tracing out the implied reaction function, since the VARs do not adequately measure effects of the federal funds rate on GDP, a major variable in the system.[36]

Financial innovation beginning in the 1980s has also changed the relationship between output and interest rate shocks. As shown in the industry VAR results in Figure 1.5, 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 order to ignore the financial sector, I replace GDP growth with non-financial growth of the corporate sector in Equation (2.2). Omitting this sector causes the aggregate non-financial corporate sector VAR impulse to have an expected contraction after a monetary tightening, as has been discussed in the literature on financial innovation [Lozej, 2012]. Figure 1.13 presents the industry responses. As shown, the subsample results in much less precise estimates of the impulse responses. Thus, all estimates need to be taken with great caution.

Figure 1.12 plots the filtered state estimates using the VAR parameters with non-financial corporate sector growth in lieu of GDP growth. The state estimate is thus a direct implication of the revenue growth rates examined in the first approach of the

[36]Note that industry responses to a federal funds rate shock are still non-zero, even though the aggregate GDP response is effectively zero. Thus, the method should measure the state from some of the industry series, although this does not provide enough power to perturb the state estimate from the structural federal funds rate equation.

paper, as it only uses corporate data as a measure of output. This specification reveals a similar monetary policy stance both before and after the zero lower bound period, but does not track the structural federal funds rate state equation of the VAR at all time. In particular, the 2009-2012 period is characterized by statistically significant contractionary monetary policy shocks. However, after this point, the estimate converges to a positive value implied by the reaction function.

As was noted in Section 2.2, fiscal policy likely had a stimulatory effect before 2012. In order to correct for bias due to fiscal policy, I omit commodity price growth in the SVARs, and include the growth rates of government spending/gross investment and tax revenues. The SVARs are identified using the following restrictions:

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

I also incorporate lagged parameter constraints. As before, industry revenues are constrained to not affect any other variables. I also omit government spending and tax revenue growth from the state-space measurement equations, as I am not interested in estimating the implied federal funds rate due to the reaction of fiscal policy to monetary policy.[37]

[37] In practice, the resulting state estimate of the federal funds rate is unaffected by any of these assumptions.

Including fiscal variables results in an implied stance that remains negative through the majority of post-2008:Q3 period (Figure 1.14). This suggests that fiscal policy was a drag on growth, positively biasing the estimate of the federal funds rate.[38] Controlling for fiscal policy results in evidence that unconventional policy succeeded in stimulating growth in corporate revenues and inflation, as the state estimate is negative.[39]

One aspect of Figures 1.14 and 1.15 is worth mentioning. The VAR prediction traces out the structural federal funds rate equation with no shocks to the federal funds rate. This line therefore reflects the desired endogenous path of the federal funds rate conditional on previous Fed behavior. The Kalman filter estimates the state as a function of disturbances to this equation. It is of note that policy was relatively less accommodative than the reaction function before 2012, whereas after 2012, policy is significantly more accommodative, and that this is statistically differentiable. The smoothed estimate is presented in Figure 1.15, which uses data from the entire sample to estimate the unobserved federal funds rate at each quarter t. This estimate yields similar dynamics relative to the reaction function: less accommodative before 2012, and more accommodative after. The smoothed estimate, however, erroneously attributes the slow down in growth before the zero lower bound period to restrictive monetary policy.

[38] This would be the case if growth in industries sensitive to interest rate changes was also sensitive to reductions in spending. The second chapter displays the growth of government consumption and gross investment, revealing that it was negative from 2009:Q4 to 2013:Q4, which is an historically unprecedented length of negative government spending growth.

[39] Various robustness checks including VAR ordering are available upon request.

The results thus far do need to be taken with a caveat, however. As mentioned previously, using the industry time series from only a twenty year period makes the impulse responses, and hence the SVAR predictions, significantly less precise (Figure 1.13). Figure 1.16 plots the impulse responses while controlling for fiscal policy.[40] The precision of the estimates is even further diminished, and the responses are also initially positive following a contractionary monetary. A simple way to try to make better use of the industry data is to reduce the lag length for all variables in the industry revenue equations. As this requires fewer parameters to be fit on the same amount of relatively noisy data, the accuracy of the estimate increases.

Figure 1.17 plots the impulse responses from this process, showing that they are much less volatile and are characterized by more plausible reactions to a contractionary monetary policy shock. Figure 1.18 plots the resulting filtered state estimate from the SVARs when industry lags are restricted to two. The state estimates reveal similar dynamics to those presented previously, though at different levels. In closing, though the technique presented here shows promise, future research is needed specifying and testing a variety of pre-zero bound models to definitively estimate the effect of unconventional policy. However, the state estimates from this section do suggest that unconventional policy was able to stimulate growth of public firms in excess of a federal funds rate of zero. In most specifications, the state estimates do not deviate from the endogenous prediction of Fed behavior. This helps inform the first part of this chapter's analysis, as it explains why we do not observe negative revenue shocks to interest rate sensitive

[40] Asymptotic standard errors are reported as the moving block bootstrap results in biased coefficients while including fiscal variables.

industries during the zero lower bound period.

1.8 Conclusion

Standard VAR approaches for capturing the effect of monetary policy assume that aggregate monetary policy responses are invariant through time.[41] In this chapter, I measure a time-invariant industry ranking of interest rate sensitivity and examine its relationship with revenue growth at the zero lower bound.

This 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. I estimate industry interest rate sensitivity using structural vector autoregressions, and provide evidence that similar revenue growth effects associated with monetary policy have occurred in the latest recovery. I comprehensively evaluate the validity of alternative explanations and robustness of the results. Fiscal policy cannot account for the growth of interest rate sensitive industries. Industry rankings are highly robust across all possible SVAR specifications, including with an alternative monetary shock measure. Controlling for firm-level variables does not diminish coefficient estimates.

In every specification examined, I find no evidence that differentials across sectors correlated with interest rate sensitivity are any different during the zero bound period. Surprisingly, in a number of specifications, I find that the zero lower bound period has greater differential revenue growth rates than unconstrained economic recovery

[41] For examining time-varying effects, see [Primiceri, 2005], who evaluates the effects of policy under the assumption that VAR parameters evolve according to a random walk.

periods. It does not seem that interest rate sensitive industries have been detrimentally affected by monetary policy, in spite of the difference between zero and the large negative federal funds rate characterized by the Federal Reserve's pre-zero lower bound reaction function

As an extension to this result, I provide a new method for measuring the realized effective federal funds rate using observed macro and industry data. This quantifies the portion of observed growth in the first part of the analysis attributable to monetary policy. I use estimated structural VAR parameters from before the zero lower bound with observed variables post-2008:Q3 to predict the federal funds rate as an unobserved variable. I find that the preferred specification, which controls for fiscal policy, closely tracks the federal funds rate in sample. Out-of-sample, I find that the measure does turn significantly negative before 2012 in all specifications, and closely tracks the Federal Reserve's pre-zero bound reaction function. This helps to explain why interest rate sensitive industries do not seem to have been detrimentally affected during the zero lower bound period.

The results presented in this chapter have important ramifications for the conduct of monetary policy at zero interest rates. In spite of the inability of the Federal Reserve to further decrease the federal funds rate, I find 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 limited ability to influence real output [Walsh, 2014]. In contrast, I find that not only does the US recovery since 2009 compare

favorably to past recoveries, but also that this fact may in part be due to unconventional monetary policy. I also find evidence that fiscal policy decreased growth, consistent with large fiscal multipliers at the zero lower bound [Christiano et al., 2011, Woodford, 2011].

One last important aspect of this chapter to note 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, 1994a]. 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 benefit public firms. Thus, it is possible that the firms examined in this chapter would be the least likely to be affected by constrained monetary policy. Further clarifying the role and transmission of unconventional policy is a worthy topic of future research, along with investigating how its effects differ from those of conventional monetary policy.

Figure 1.1: Log Real Mean Revenues, Selected Industries

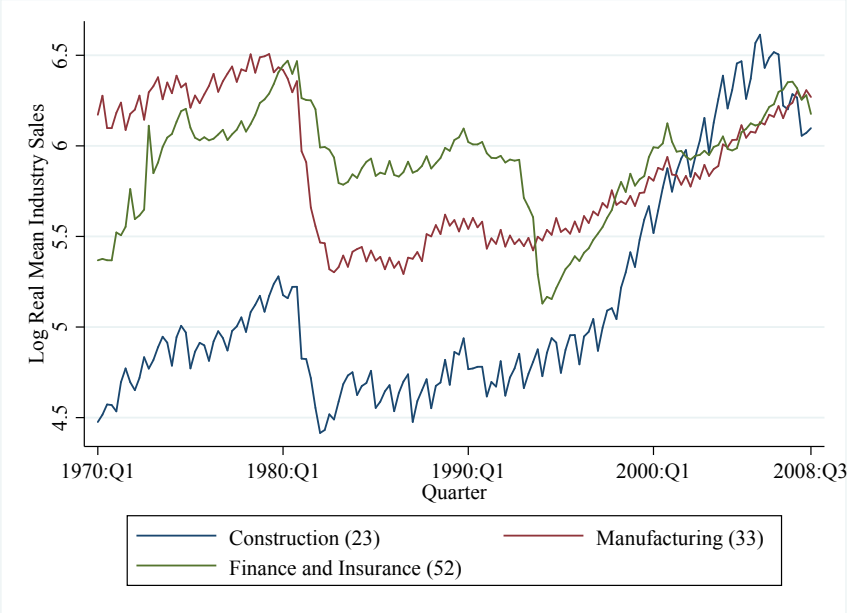

Figure 1.2: Quarterly industry revenues: 2005Q1-2008Q3.

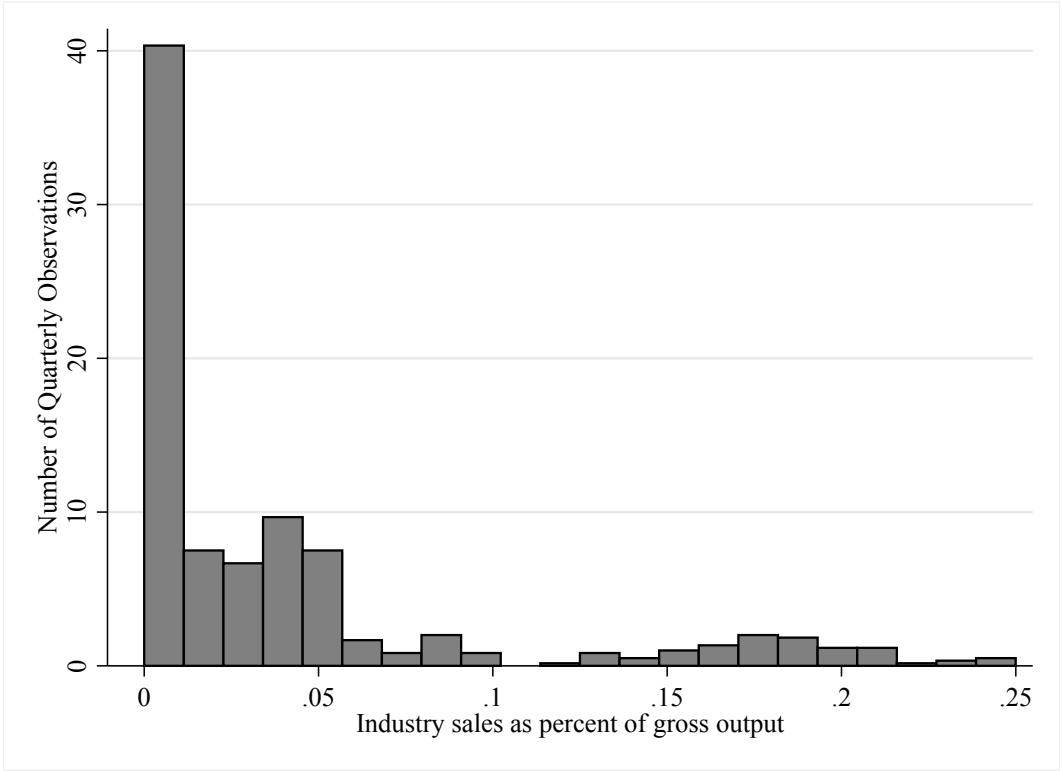

Figure 1.3: Average Number of Quarterly Firm Observations by North American Industrial Classification Code, 1970:Q1-2008:Q3

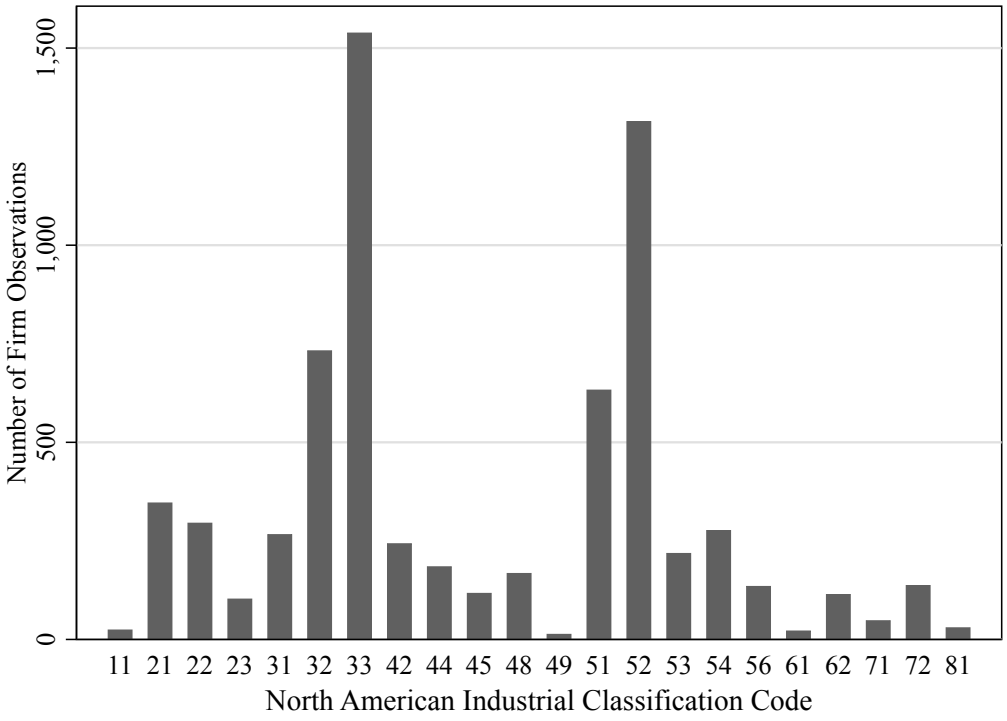

Figure 1.4: Constructed Industry Time Series

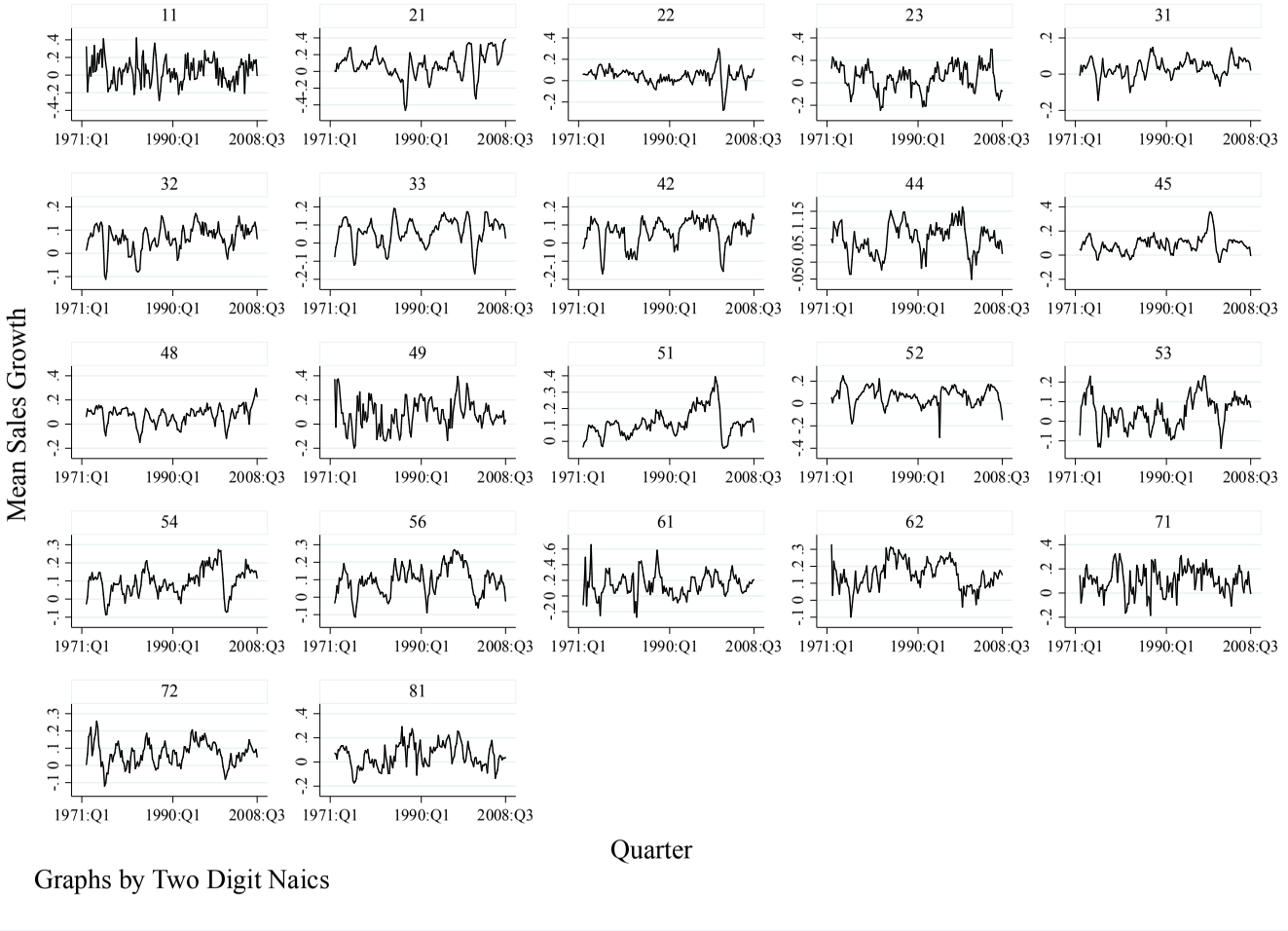

Figure 1.5: Industry orthogonalized responses to one standard deviation federal funds rate shock, 1971:Q1-2008:Q3. The x-axes denote quarters. 90% confidence intervals using circular moving block bootstrap bootstrap outlined in blue.

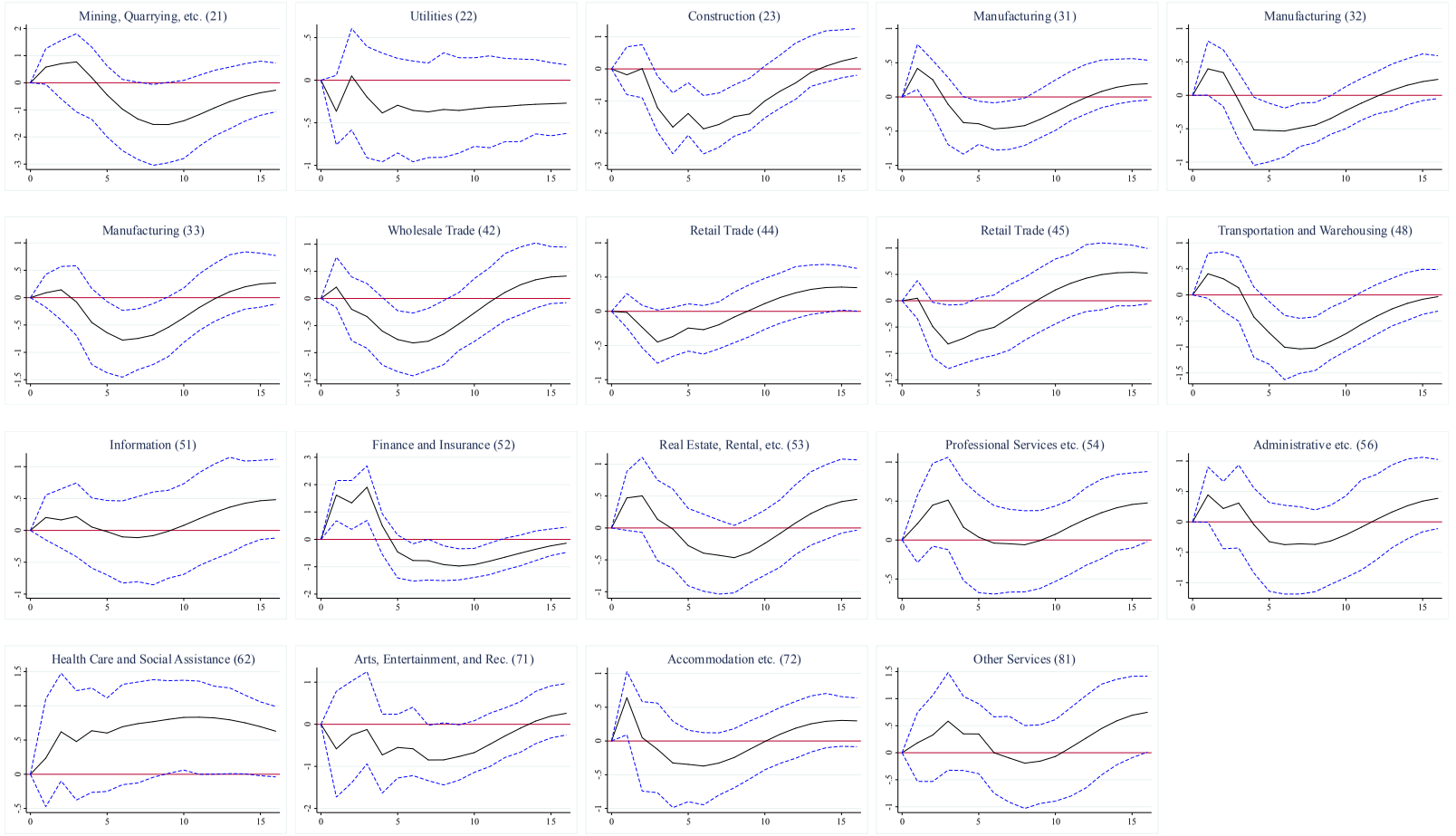

Figure 1.6: Aggregate orthogonalized responses to one standard deviation shocks by impulse variable, response variable. The x-axes denote quarters. 90% confidence intervals using circular bootstrap outlined in blue.

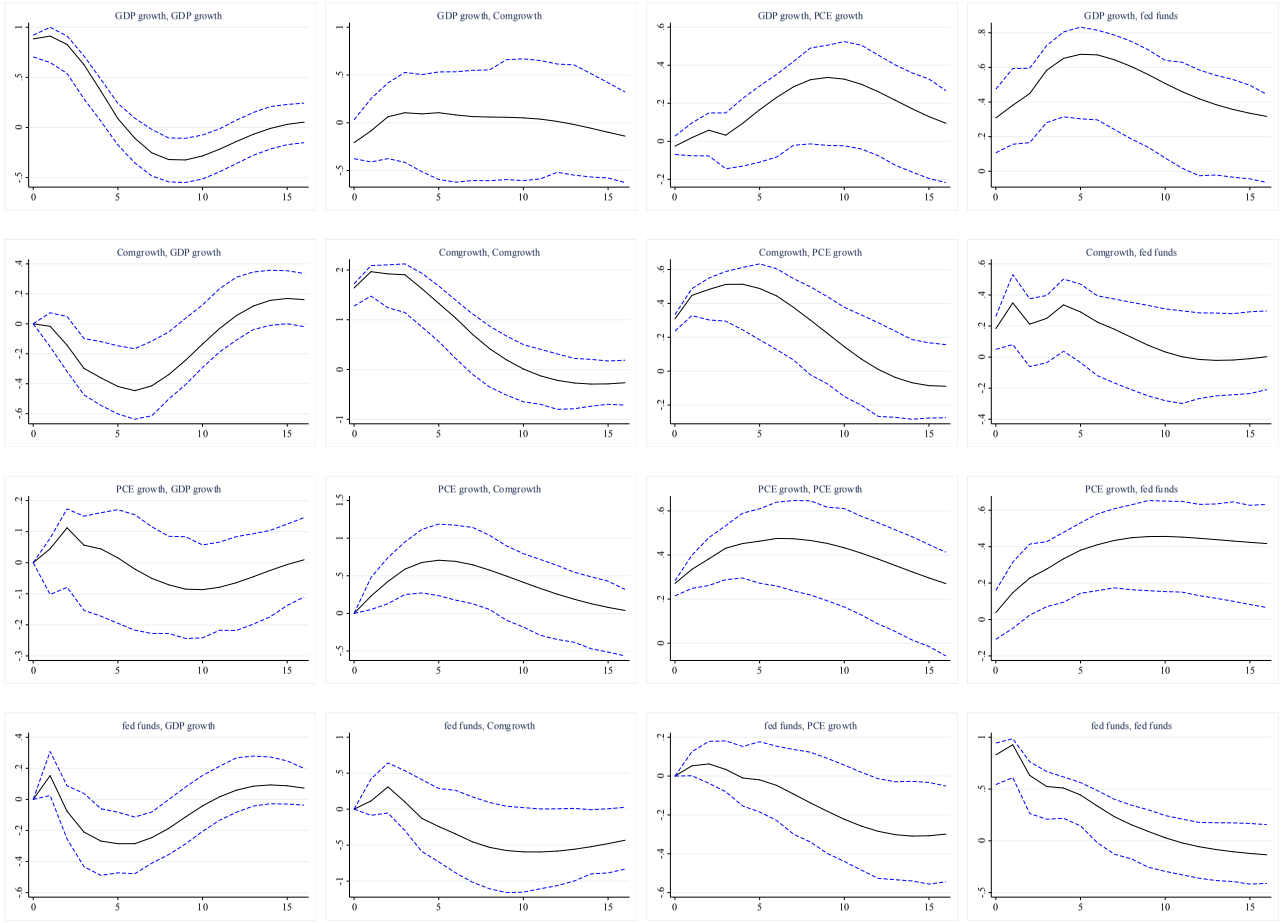

Figure 1.7: Coefficient estimates of a one standard deviation increase in index sensitivity. Dependent variable: rolling three year revenue growth.

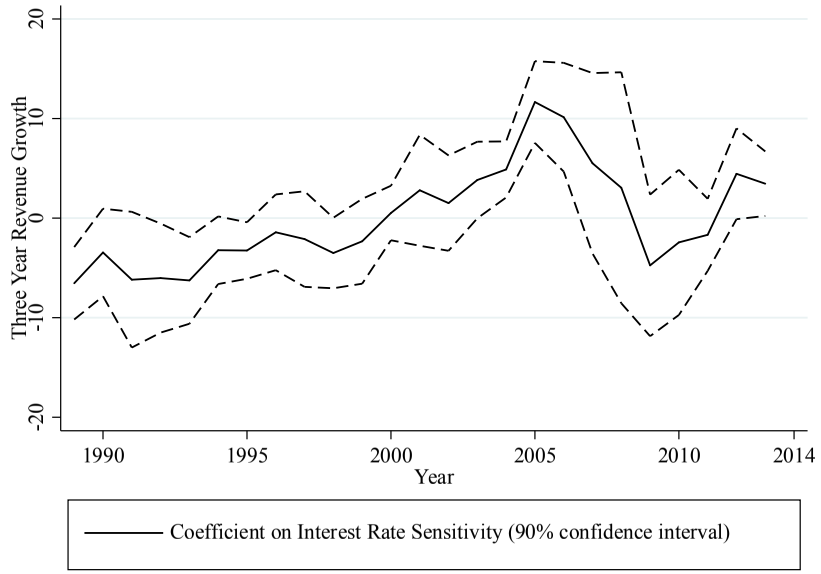

Figure 1.8: Industry growth rates and interest rate sensitivity, 95% confidence intervals in grey. Each industry labeled with North American Industry Classification Code.

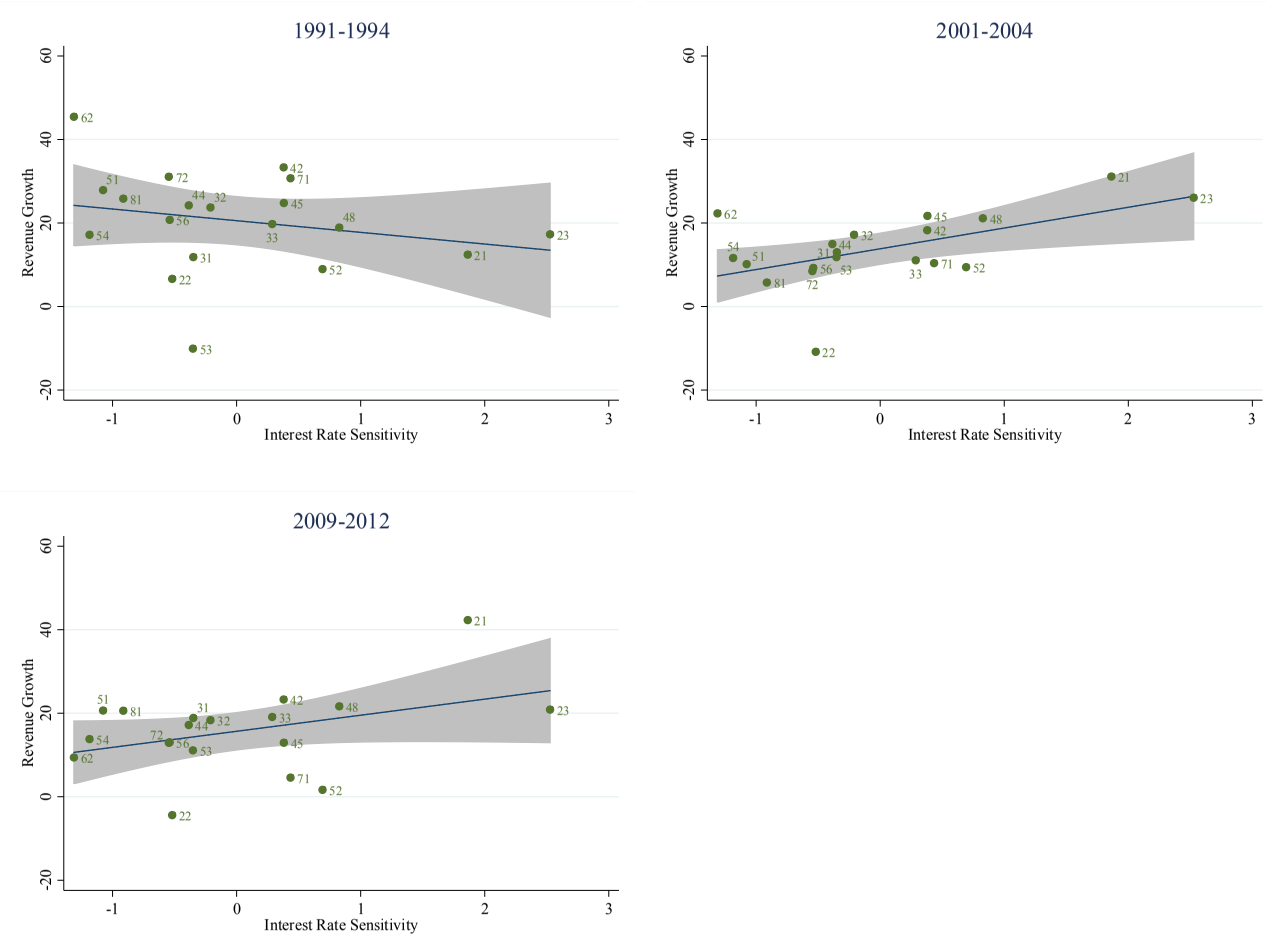

Figure 1.9: Industry Multi-Factor Productivity Growth and Interest Rate Sensitivity Index

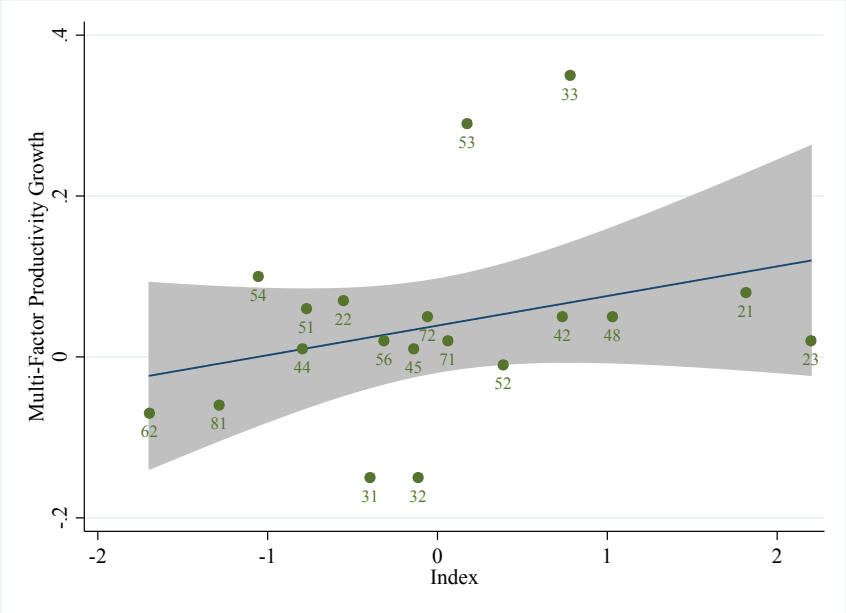

Figure 1.10: Implied Stance of Monetary Policy

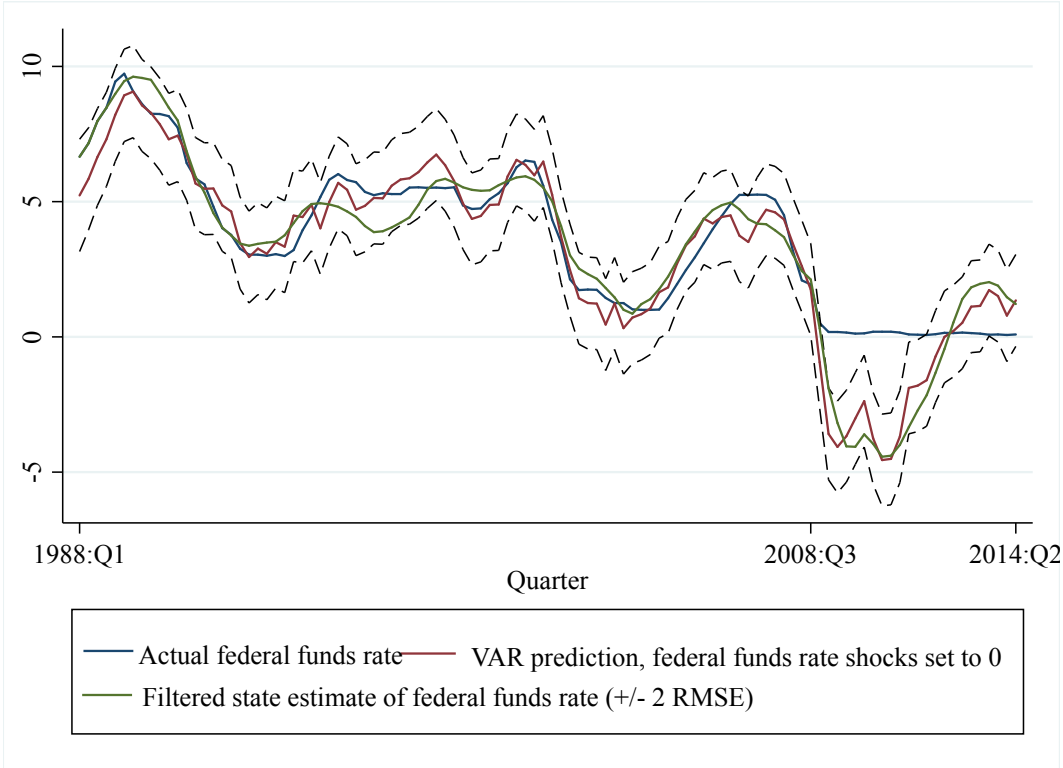

Figure 1.11: VAR Results post-1988:Q1: GDP growth, Commodity Price Growth, PCE Growth, federal funds rate. The x-axes denote quarters. 90% confidence intervals using circular moving block bootstrap bootstrap outlined in blue. Orthogonalized impulse responses presented by impulse, response.

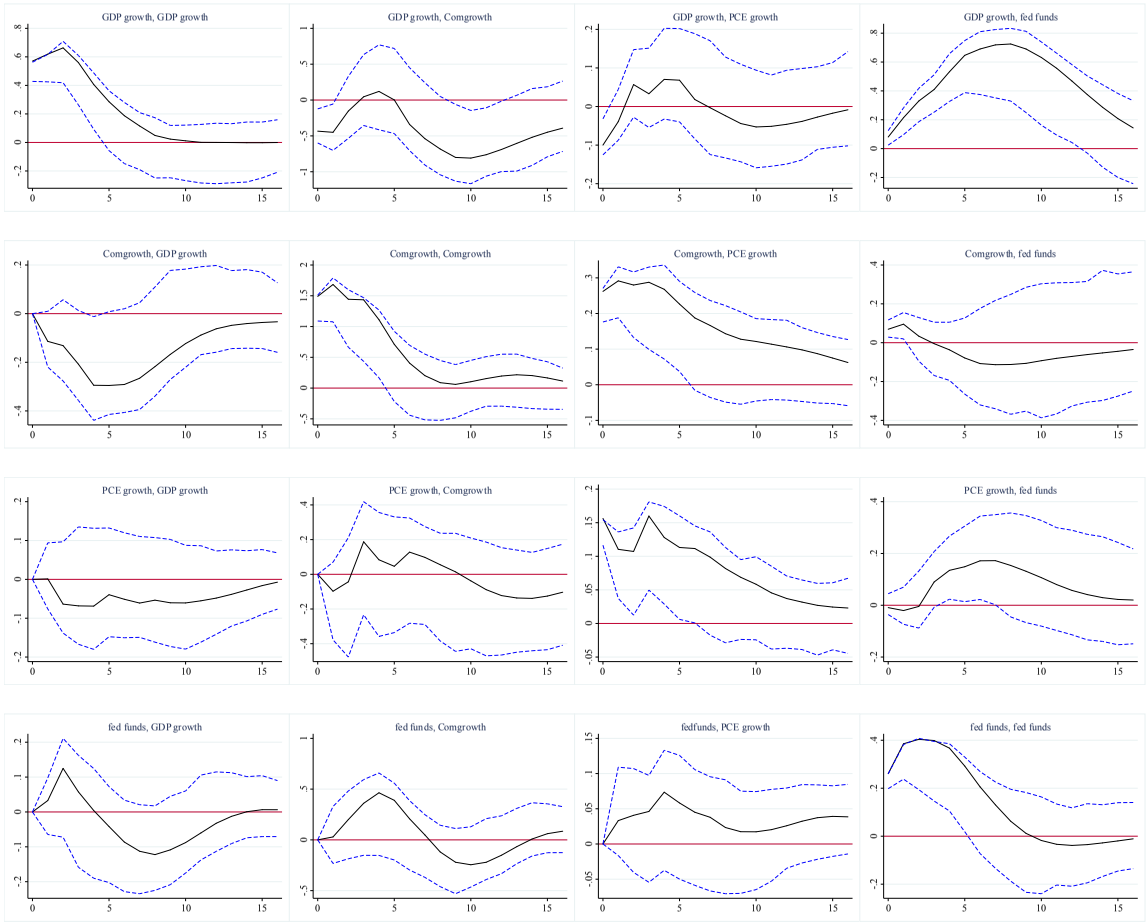

Figure 1.12: Implied Stance of Monetary Policy: Non-Financial Corporate Output Growth in Place of GDP Growth

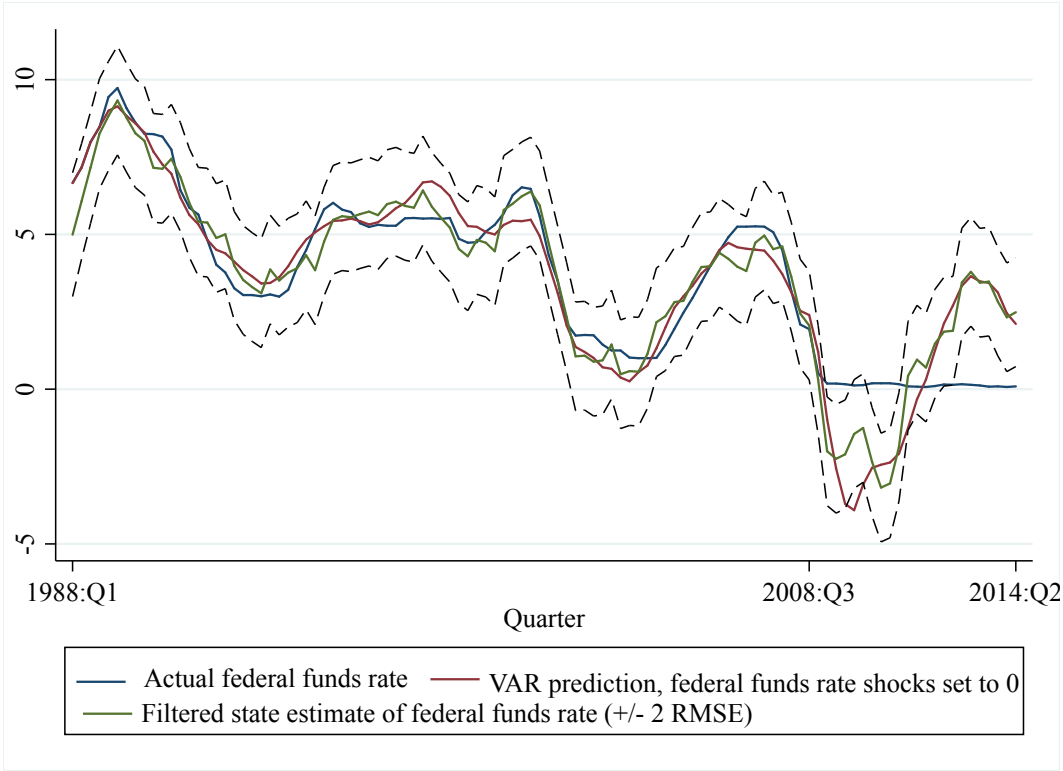

Figure 1.13: Industry orthogonalized responses to a one standard deviation federal funds rate shock, 1988:Q1-2008:Q3. SVARs variables are corporate output growth, industry revenue growth, commodity price growth, PCE growth, and the federal funds rate. The x-axes denote quarters. 90% circular moving block bootstrap confidence intervals outlined in blue.

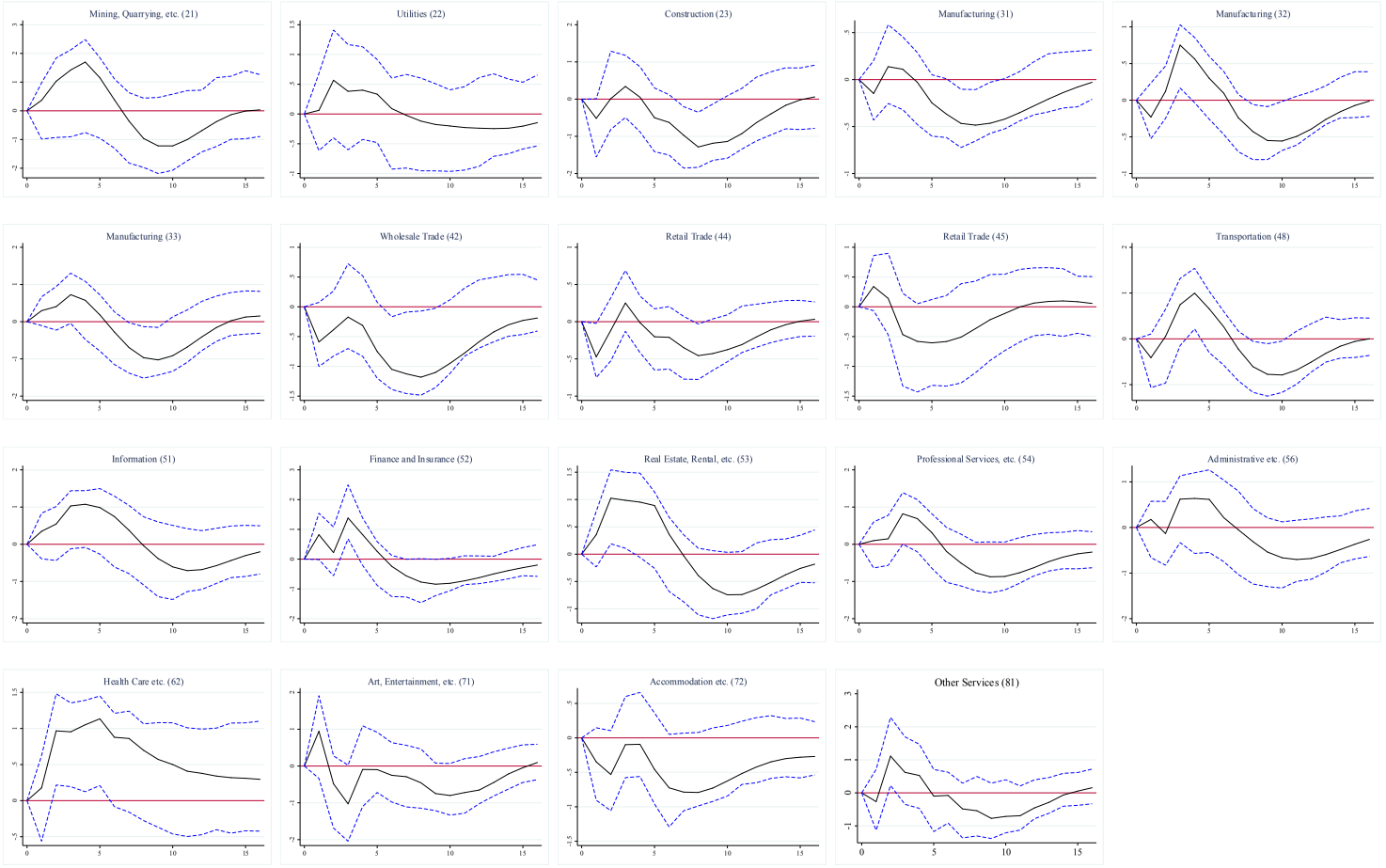

Figure 1.14: Implied Stance of Monetary Policy: NFC Output Growth, Controlling for Fiscal Policy

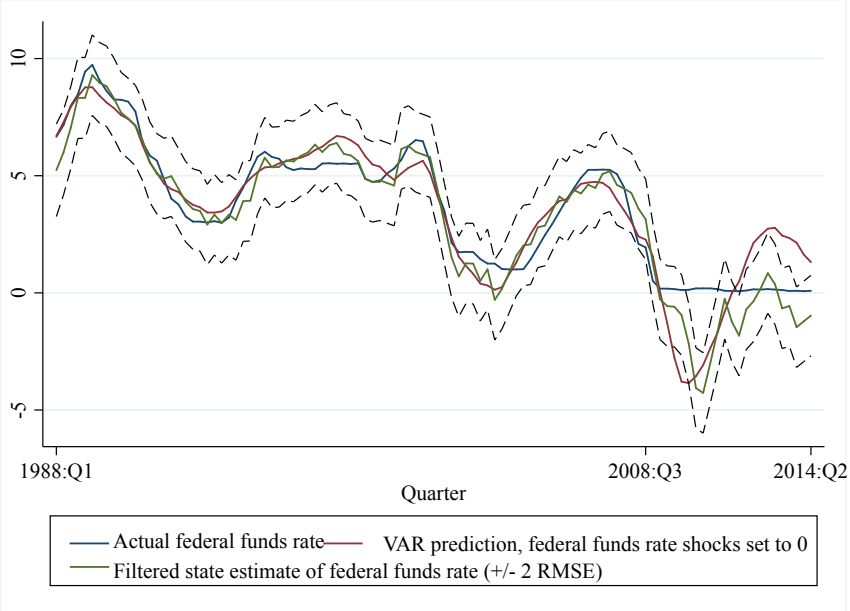

Figure 1.15: Implied Stance of Monetary Policy: NFC Output Growth, Controlling for Fiscal Policy, Smoothed Estimate

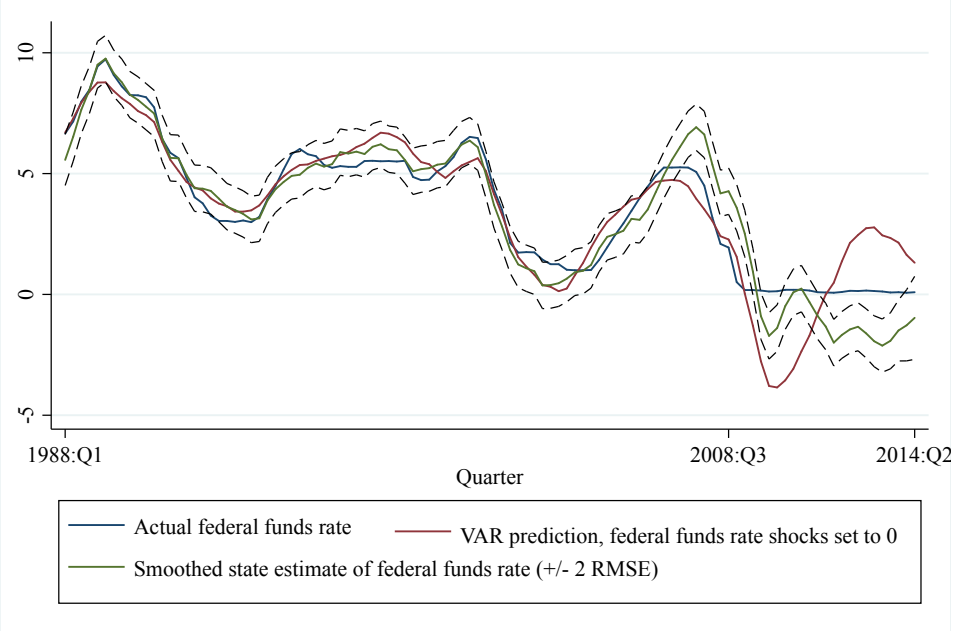

Figure 1.16: Industry orthogonalized responses to a one standard deviation federal funds rate shock, 1988:Q1-2008:Q3. SVARs variables are government spending growth, tax growth, non-financial corporate output growth, industry revenue growth, PCE growth, and the federal funds rate. The x-axes denote quarters. 90% asymptotic confidence intervals outlined in blue.

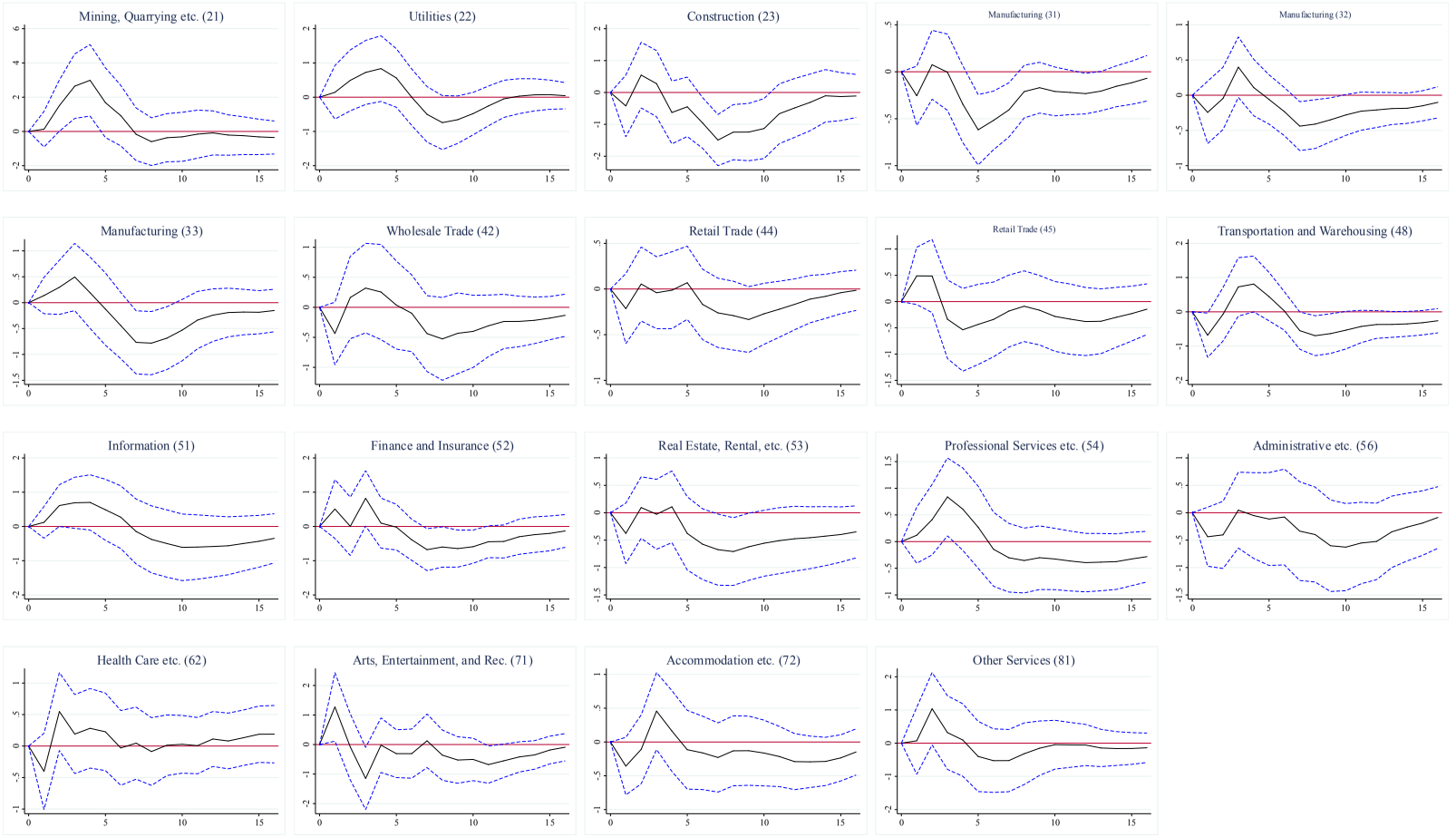

Figure 1.17: Industry orthogonalized responses to a one standard deviation federal funds rate shock, 1988:Q1-2008:Q3. SVARs variables are government spending growth, tax growth, non-financial corporate output growth, industry revenue growth, PCE growth, and the federal funds rate. The x-axes denote quarters. 90% asymptotic confidence intervals outlined in blue. Industry equations restricted to lag lengths of two.

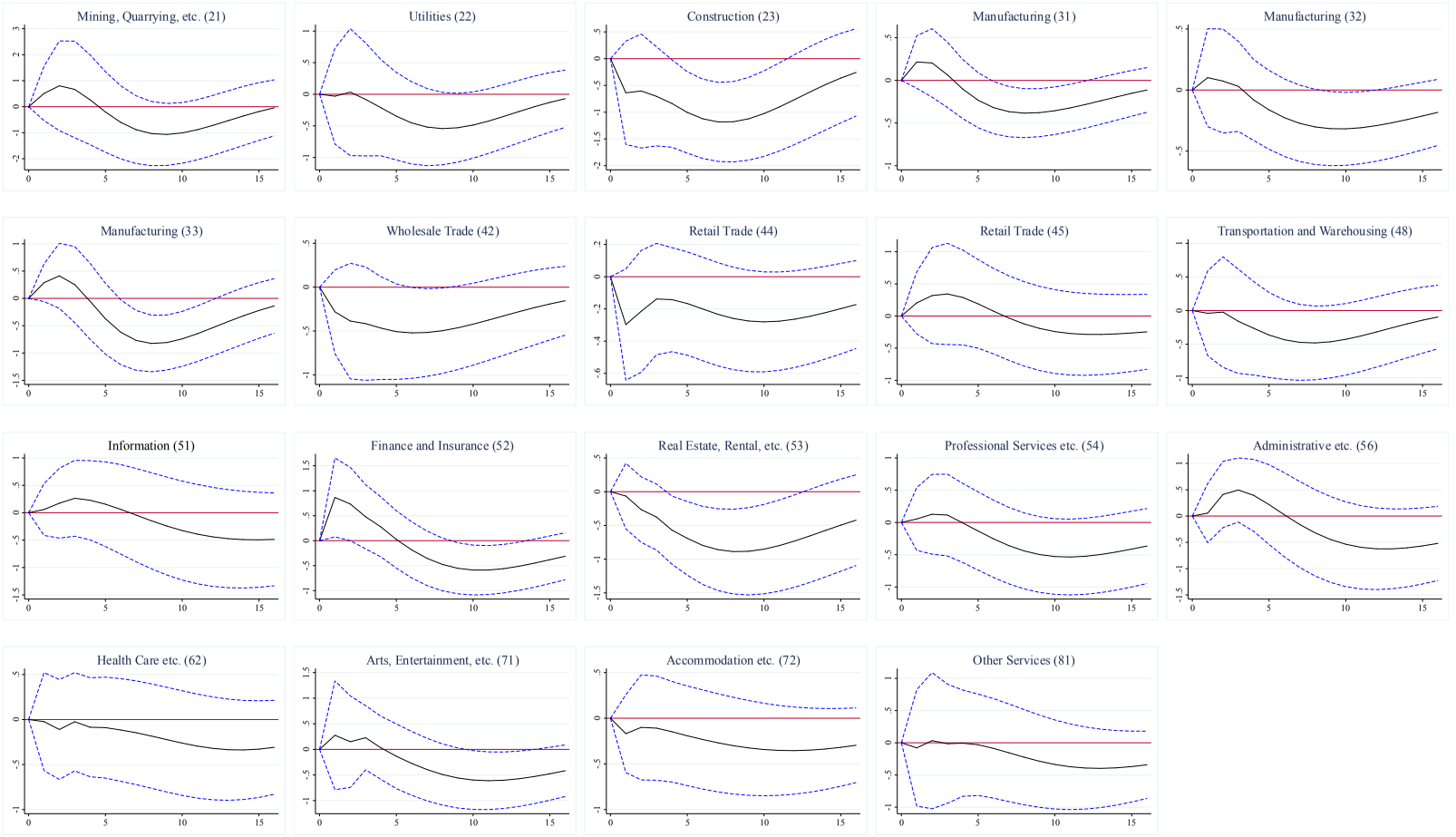

Figure 1.18: Implied Stance of Monetary Policy: NFC Output Growth, Controlling for Fiscal Policy. Structural Industry Equations Restricted to Lag Length of Two

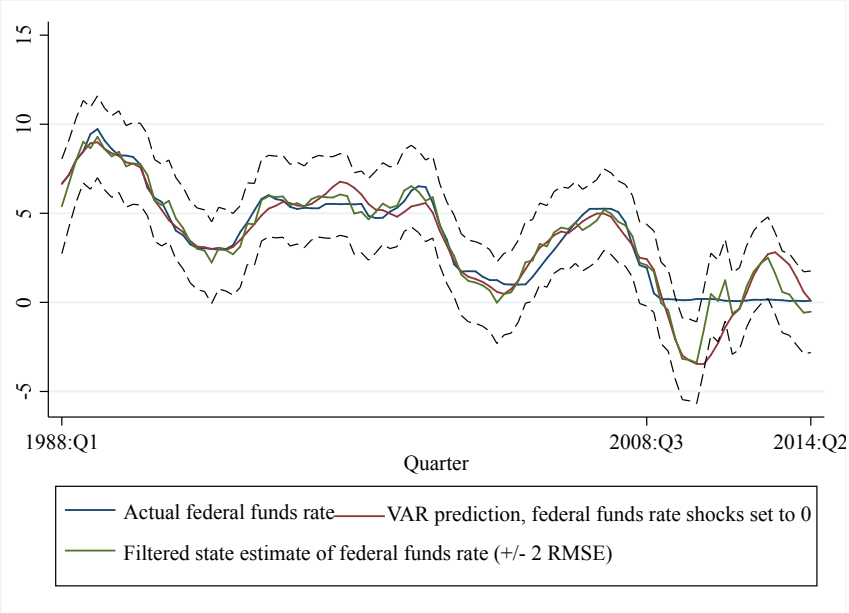

Table 1.1: Mean Industry Revenue Growth: 1971:Q1-2008:Q3

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

Table 1.2: 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

Table 1.3: 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 1.4: Real Revenue Growth, Baseline Specification

	(1)	(2)	(3)	(4)
Index	-0.050	0.715	0.550	0.878
	(1.809)	(2.599)	(2.418)	(2.730)
Index·2012	2.302	2.487	2.680	2.685
	(3.745)	(3.107)	(3.220)	(3.227)
Elasticity·1994		4.545**	4.112**	4.432**
		(1.856)	(1.739)	(1.813)
Elasticity·2004		-0.417	0.050	0.193
		(3.622)	(3.501)	(3.369)
Elasticity·2012		1.663	1.277	1.545
		(4.378)	(4.267)	(4.042)
Emp·1991			-6.038***	-6.004***
			(0.941)	(0.944)
Emp·2001			0.336	0.449
			(0.672)	(0.695)
Emp·2009			-0.028	0.056
			(0.632)	(0.615)
TrendGrowth				-319.437
				(528.768)
1991-1994	12.641*	4.908	10.433	12.552*
	(6.264)	(10.952)	(6.464)	(6.531)
2001-2004	7.881	10.795	6.205	8.464
	(12.206)	(14.692)	(13.805)	(13.712)
2009-2012	4.008	0.965	-0.003	1.969
	(11.679)	(10.246)	(13.127)	(13.554)
Observations	17,723	17,723	16,480	16,480
Adjusted R-squared	0.070	0.072	0.070	0.070

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors clustered at NAIC 2 digit level in parentheses. Includes fiscal year end indicators interacted with each recovery period to control for firm month reporting differences.

Table 1.5: Real Revenue Growth, Bootstrapped Standard Errors Accounting for Generated Regressors

	(1)	(2)	(3)	(4)
Index	-0.050	0.715	0.550	0.878
	(1.198)	(1.722)	(1.552)	(1.626)
Index·2012	2.302	2.487	2.680	2.685
	(2.887)	(3.673)	(3.935)	(3.929)
Elasticity·1994		4.545***	4.112***	4.432***
		(0.856)	(0.683)	(0.717)
Elasticity·2004		-0.417	0.050	0.193
		(0.831)	(0.749)	(0.769)
Elasticity·2012		1.663	1.277	1.545
		(4.378)	(4.267)	(4.042)
Emp·1991			-6.038***	-6.004***
			(0.082)	(0.086)
Emp·2001			0.336***	0.449***
			(0.065)	(0.090)
Emp·2009			-0.028	0.056
			(0.179)	(0.194)
TrendGrowth				-319.437***
				(108.518)
1991-1994	12.641***	4.908***	10.433***	12.552***
	(2.217)	(2.585)	(1.601)	(1.617)
2001-2004	7.881***	10.795***	6.205	8.464***
	(1.742)	(2.159)	(1.552)	(1.469)
2009-2012	4.008	0.965	-0.003	1.969
	(2.352)	(4.724)	(4.055)	(3.769)
Observations	17,723	17,723	16,480	16,480
Adjusted R-squared	0.070	0.072	0.070	0.070

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors clustered at NAIC 2 digit level in parentheses. Includes fiscal year end indicators interacted with each recovery period to control for firm month reporting differences.

Table 1.6: Real Revenue Growth: Pre-trends

	(1)	(2)	(3)	(4)
Index	-4.776	-4.911*	-4.309*	-3.737*
	(4.022)	(2.717)	(2.218)	(1.981)
Index·2009	-0.935	-2.778	-3.674	-3.695
	(2.983)	(2.855)	(2.488)	(2.444)
Elasticity·1991		-1.278	-1.341	-0.772
		(2.274)	(2.330)	(2.017)
Elasticity·2001		0.333	-4.497	-4.145
		(5.076)	(3.367)	(3.237)
Elasticity·2009		-3.480	-3.499	-3.097
		(3.105)	(2.894)	(2.383)
Emp·1988			-3.046***	-2.970***
			(0.953)	(0.943)
Emp·1998			-3.665***	-3.479***
			(0.831)	(0.731)
Emp·2006			-2.353***	-2.184**
			(0.754)	(0.805)
TrendGrowth				-569.462
				(416.703)
1988-1991	15.419*	14.762	15.180	19.716*
	(8.150)	(12.159)	(9.520)	(10.212)
1998-2001	7.622	7.027	35.896	40.424
	(5.609)	(8.779)	(23.294)	(24.579)
2006-2009	1.520	7.312	10.352*	14.862**
	(3.962)	(6.190)	(5.815)	(6.324)
Observations	18,333	18,333	16,313	16,313
Adjusted R-squared	0.066	0.066	0.043	0.044

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors clustered at NAIC 2 digit level in parentheses. Includes fiscal year end indicators interacted with each recovery period to control for firm month reporting differences. Log employment controls are firm-level in 1988, 1998, and 2006.

Table 1.7: Real Revenue Growth: Controlling for Mean Reversion

	(1)	(2)	(3)	(4)
Index	1.894	2.161	2.588	3.045
	(1.318)	(1.856)	(1.823)	(1.862)
Index·2012	0.746	1.599	1.607	1.599
	(3.199)	(2.876)	(2.891)	(2.889)
Lagged Growth	0.047***	0.048***	0.049***	0.047***
	(0.016)	(0.015)	(0.014)	(0.014)
Elasticity·1994		2.367*	2.487*	2.927**
		(1.298)	(1.387)	(1.261)
Elasticity·2004		-0.577	-0.235	-0.033
		(3.068)	(3.198)	(2.885)
Elasticity·2012		2.032	1.523	1.877
		(3.745)	(3.749)	(3.383)
Emp·1991			-0.086	-0.043
			(1.102)	(1.107)
Emp·2001			4.208***	4.370***
			(0.593)	(0.610)
Emp·2009			2.933***	3.035***
			(0.460)	(0.447)
TrendGrowth				-473.078
				(429.273)
1991-1994	7.955	2.954	-1.836	2.157
	(5.853)	(10.109)	(12.743)	(12.480)
2001-2004	4.343	4.418	-1.721	2.327
	(12.496)	(8.778)	(7.660)	(6.764)
2009-2012	3.802	-0.675	-8.222	-4.354
	(11.706)	(8.636)	(12.768)	(12.167)
Observations	14,734	14,734	14,157	14,157
Adjusted R-squared	0.043	0.044	0.054	0.055

**** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors clustered at NAIC 2 digit level in parentheses. Includes fiscal year end indicators interacted with each recovery period to control for firm month reporting differences. Log employment controls are firm-level in 1991, 1994, and 2009

Chapter 2

Further analysis of industry growth at the zero lower bound

The results of the preceding chapter, while interesting, may not be entirely convincing without a thorough examination of specifications choices and alternative explanations for the findings. This chapter expands upon the work presented, and shows that the findings are highly unlikely to have occurred due to other factors. Similarly, a variety of specification choices are tested, resulting in the same findings suggestive of monetary policy effectiveness at the zero bound.

2.1 Robustness

2.1.1 Alternative Interest Rate Sensitivity Indices

Is the ranking of industry sensitivities to interest rates influenced by the manner of construction? As shown in Figure 1.5, 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 2.1 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 2.2 shows that the 2009 interest rate sensitivity coefficients 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.

As mentioned in Section 1.4, the ordering of the SVARs was chosen in accordance with the literature. Nonetheless, the index and the second stage results are unaffected by ordering. in the second chapter, I show that 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 2.3 presents correlations of the indices with a number of other specifications of the SVARs, while Table 2.4 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 for reasons described in Section 1.4. 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 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 2.3 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 2.4 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.

As a last check on the VAR results, I show in the second chapter that lag length

selection is unimportant, though the magnitude and significance of the index coefficient at the zero lower bound are diminished. In conclusion, the VARs are remarkably robust across all specifications in the outcome of the industry ordering, and the second stage results.

2.1.2 Further Second Stage Difference-in-Difference 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 2.5, 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 standard errors may overstate significance [Bertrand et al., 2004].

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 2.6 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 2.7), 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 chapter. In that case, most regressions would show increased growth of interest rate sensitive industries at the zero lower bound.

The index ϕ is itself actually a generated variable, $\hat{\phi}$, whose uncertainty has not been taken into account thus far. Table 1.5 bootstraps over all possible indices to adjust for this.[1] The standard errors correcting for generated regressors are largely comparable to the industry-clustered standard errors.

in the second chapter, I show that the results are similar when examining alternative years, including post-2011 data. Furthermore, controlling for tax sensitivity index results in a similarly increased coefficient on interest rate sensitivity at the zero lower bound for other years examined.

[1] [Pagan, 1984] has shown that equation (1.6) 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. Then, equation (1.6) is run on each of the 200 indices, yielding a distribution of coefficient estimates for each independent variable encompassing the entire distribution of possible indices. The standard deviations of the point estimates are then the bootstrapped standard errors of the coefficients. Since the question of interest in this chapter is the effect of monetary policy during the zero lower bound in the US, I do not bootstrap the second stage at the firm level. The uncertainty at the firm level is ignored since the sample of corporate firms is the entire population, and the question this chapter asks is whether the post-2008 realization of firm outcomes is different from previous recoveries.

2.1.3 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.[2] 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 (1.4), with the cumulative new shock measure in place of the federal funds rate.[3]

I construct the index using the SVAR impulse responses in the same fashion as explained in Section 1.5.1. The resulting industry ordering using R&R has a correlation of 0.85 with the baseline SVAR index, and is highly significant (Table 2.8). Thus, using the federal funds rate or the R&R shock measure results in a very similar industry ordering providing evidence that is correctly measured. Table 2.9 reveals that the second stage difference-in-difference 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.

[2]The shock series, updated and used from 1971:Q1-2007:Q4, can be obtained from Silvia Tenreyro's website at http://personal.lse.ac.uk/tenreyro/.

[3]The 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.

2.2 Possible Alternative Explanations

2.2.1 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.

In fact, 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 2.10 presents real revenues over employment growth, for a measure of labor productivity.[4] In none of the the recoveries is the index significant, meaning that firm labor productivity growth in interest rate sensitive industries was not significantly different from zero.

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-

[4]Bureau of Labor Statstics 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.

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.[5].

Figure 1.9 presents scatter plots and an ols regression of the sensitivity index and multi-factor productivity growth from 2009-2012[6] 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. Further details using regression analysis can be found in the second chapter.[7]

2.2.2 The American Recovery and Reinvestment Act of 2009

One observationally equivalent explanation for the positive coefficient on interest rate sensitivity from 2009-2012 is that fiscal policy in interest rate sensitive industries 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

[5]Classifications from the Statistics Canada. The 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.

[6]These 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.

[7]Including multi-factor productivity growth leaves coefficient estimates in the regression largely unchanged, but increases the standard errors.

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. Thus, these papers suggest that fiscal policy was not a relevant confounder during the zero lower bound period.

Other evidence from the Congressional Budget Office's estimates of ARRA also suggests that it is not likely a relevant ommitted variable. Table 2.11 presents ex-post estimates of ARRA's effects on real GDP growth. As shown in the table, the estimates of ARRA's effects in 2012 are actually smaller than its estimated effects in 2009. Thus, cyclically-sensitive sectors actually had greater output in 2009 relative to 2012 as result of ARRA's effects. One would expect fiscal policy to affect cyclically-sensitive sectors similarly to those affected by monetary policy. This implies that regression estimates of growth due to interest rate sensitivity from 2009-2012 would actually be biased downwards due to fiscal policy, rather than upwards.

The CBO's estimates 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 that effects die out to 0 by the first quarter of 2012. The output effects in 2009 reach a maximum of 0.3% of GDP in quarter 3. Thus, [Cogan et al., 2010]'s results would also suggest that the net effect of fiscal policy would bias results against finding an effect of monetary policy.

2.2.3 Cash for Clunkers

In 2009, the US Federal government also initiated the Car Allowance Rebate System, known as "Cash for Clunkers". The program provided $3 billion in incentives for residents to replace old vehicles with more fuel efficient cars. Could this fiscal program have made it seem that monetary policy was effective? [Mian and Sufi, 2012] examined the effects of the program and found that it shifted automobile purchases forward from the future, rather than create any new demand for vehicles. This particular program also biases the results in the opposite direction; firms involved in auto revenues would have had elevated revenues at the start of the recovery period (2009), and possibly diminished revenues at the end of the recovery periods examined (2011-2012).

2.3 Implied Stance Variations

2.3.1 Using Pre-Great Moderation Data

Figure 2.4 plots a similar estimation process as in 1.14. However, in this case that VARs are run on data from 1971:Q1-2008:Q3; likewise, the filter is also run over this time period. The estimates of the state are much more uncertain, partly due to the changes in the Federal Reserve's reaction function over this long time period encompassing both the Volcker disinflation and the great inflation. Nonetheless, the estimate is significantly negative before 2012, though it is is indistinguishable from 0 following that point.

2.3.2 Using Romer and Romer Shocks with a Random Walk

Figure 2.5 plots another variation on the implied stance. In lieu of the VAR identified monetary shocks, this figure is based upon cumulative Romer and Romer shocks in place of the federal funds rate. Furthermore, the state equation is allowed to follow a random walk[8] This has the added benefit of not incorporating any of the Federal Reserve's reaction function into the estimation process. Formally, the state-space system is set up in the following manner:

$$Z_t = Z_{t-1} + u_{5t} \tag{2.1}$$

$$X_t = \hat{C} + \hat{F}(L)W_t + \hat{\Lambda}(L)Z_{t-1} + \zeta_t \tag{2.2}$$

Thus, at any quarter, the Kalman filter agnostically optimizes the estimate of the unobserved cumulative Romer and Romer shocks, treating increases or decreases in the shocks as equally likely.

As shown in Figure 2.5, the filter correctly identifies the Romer and Romer shocks within the VAR sample. Furthermore, using the Romer and Romer shocks in this highly unstructured form with a random walk state equation still results in expansionary monetary shocks after 2009. The unobserved "exogenous" interest rate movements are measured to trough at roughly 3%, are at times significantly negative, and include a desired range of -5% within the confidence bands. This provides further evidence that

[8]Note that the Romer and Romer shocks should be unpredictable, meaning that the state equation should not need any structure.

Table 2.1: 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.

unconventional policy was effective in stimulating growth. However, it is important to note that the Romer and Romer shocks are the "exogenous" interest rate movements, meaning that the negative shocks signify that the estimation is measuring expansionary shocks *in excess* of previous behavior. Thus, the Romer and Romer shock series present an even more favorable characterization of monetary policy at the zero lower bound.

Table 2.2: Alternative Index Construction

	(1) Baseline	(2) Sirf7	(3) Csirf16
Index	0.878	-0.896	-1.437
	(2.730)	(2.970)	(3.064)
Index·2012	2.685	5.610*	7.129**
	(3.227)	(3.033)	(3.022)
Elasticity·1994	4.432**	3.857**	3.586**
	(1.813)	(1.610)	(1.690)
Elasticity·2004	0.193	-0.545	-0.824
	(3.369)	(3.389)	(3.230)
Elasticity·2012	1.545	1.507	2.219
	(4.042)	(4.048)	(4.367)
Emp·1991	-6.004***	-6.109***	-6.094***
	(0.944)	(0.946)	(0.944)
Emp·2001	0.449	0.362	0.389
	(0.695)	(0.725)	(0.728)
Emp·2009	0.056	0.101	-0.028
	(0.615)	(0.629)	(0.650)
TrendGrowth	-319.437	-263.542	-268.205
	(528.768)	(483.371)	(493.615)
1991-1994	12.552*	13.350*	14.235
	(6.531)	(6.424)	(11.550)
2001-2004	8.464	10.087	12.680
	(13.712)	(13.295)	(15.114)
2009-2012	1.969	1.805	1.378
	(13.554)	(13.177)	(11.792)
Observations	16,480	16,480	16,480
Adjusted R-squared	0.070	0.071	0.071

*** 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. Includes fiscal year end indicators interacted with each recovery period to control for firm month reporting differences.

Table 2.3: 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 2.4: Alternative Specifications

	(1) Baseline	(2) Quarter Dummies	(3) No Commodity Prices	(4) All Sectors	(5) Post 1988Q1
Index	0.878	0.685	1.397	1.190	1.396
	(2.730)	(2.770)	(2.627)	(3.041)	(1.734)
Index·2012	2.685	1.575	5.214	2.773	6.959***
	(3.227)	(3.321)	(3.051)	(3.323)	(1.771)
Elasticity·1994	4.432**	4.362**	4.770**	4.426**	4.581**
	(1.813)	(1.830)	(2.056)	(1.804)	(1.703)
Elasticity·2004	0.193	0.120	0.508	0.352	0.188
	(3.369)	(3.474)	(3.264)	(3.319)	(2.688)
Elasticity·2012	1.545	0.947	3.458	1.440	3.091
	(4.042)	(4.462)	(3.614)	(4.048)	(2.719)
Emp·1991	-6.004***	-6.019***	-5.980***	-6.008***	-5.876***
	(0.944)	(0.941)	(0.943)	(0.929)	(0.983)
Emp·2001	0.449	0.438	0.461	0.491	0.505
	(0.695)	(0.694)	(0.712)	(0.681)	(0.686)
Emp·2009	0.056	0.001	0.090	-0.062	0.282
	(0.615)	(0.619)	(0.628)	(0.634)	(0.587)
TrendGrowth	-319.437	-305.970	-399.580	-306.416	-433.642
	(528.768)	(547.858)	(555.642)	(518.123)	(495.639)
1991-1994	12.552*	12.589*	13.705	4.073	13.032*
	(6.531)	(6.491)	(11.125)	(11.362)	(7.062)
2001-2004	8.464	8.354	11.675	18.875	10.159
	(13.712)	(13.745)	(14.592)	(13.065)	(14.004)
2009-2012	1.969	2.794	0.740	9.985	0.454
	(13.554)	(13.675)	(10.659)	(10.652)	(14.088)
Observations	16,480	16,480	16,480	16,634	16,480
Adjusted R-squared	0.070	0.070	0.072	0.071	0.074

*** p<0.01, ** p<0.05, * p<0.1. Industry standard errors clustered in parentheses. Includes fiscal year end indicators interacted with each recovery period to control for firm month reporting differences.

Table 2.5: Real Revenue Growth, Balanced Subsample

	(1)	(2)	(3)	(4)
Index	1.973	2.961	2.668	3.061
	(3.084)	(3.373)	(3.118)	(2.660)
Index·2012	1.401	1.205	1.379	1.260
	(2.196)	(2.186)	(2.085)	(2.119)
Elasticity·1994		5.784*	5.963**	6.564***
		(2.962)	(2.714)	(1.734)
Elasticity·2004		2.352	2.571	3.114
		(4.867)	(4.944)	(4.234)
Elasticity·2012		2.371	2.469	3.072
		(2.938)	(2.933)	(2.158)
Emp·1991			-6.167***	-6.153***
			(0.792)	(0.790)
Emp·2001			-0.194	-0.119
			(1.218)	(1.210)
Emp·2009			0.204	0.242
			(0.716)	(0.694)
TrendGrowth				-973.569*
				(530.965)
1991-1994	43.651***	33.207**	26.982**	35.427***
	(11.350)	(12.289)	(9.749)	(9.590)
2001-2004	21.488*	17.843	10.630	19.380
	(11.634)	(13.339)	(19.815)	(18.626)
2009-2012	21.111	22.408***	21.926**	29.826***
	(20.575)	(7.687)	(8.021)	(7.993)
Observations	5,185	5,185	4,965	4,965
Adjusted R-squared	0.110	0.113	0.117	0.121

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors clustered at NAIC 2 digit level in parentheses. Includes fiscal year end indicators interacted with each recovery period to control for firm month reporting differences.

Table 2.6: Real Revenue Growth, Industry-Level Data

	(1)	(2)	(3)	(4)
Index	1.087	1.398	1.615	1.643
	(1.701)	(1.774)	(1.829)	(1.857)
Index·2012	2.762	2.344	2.233	2.260
	(2.947)	(3.073)	(3.228)	(3.267)
Elasticity·1994		2.870	2.806	2.903
		(2.627)	(2.675)	(2.767)
Elasticity·2004		0.136	0.206	0.291
		(2.627)	(2.684)	(2.761)
Elasticity·2012		-0.520	-0.563	-0.484
		(2.659)	(2.723)	(2.795)
Emp·1991			6.613	6.672
			(5.936)	(6.010)
Emp·2001			-0.384	-0.116
			(5.346)	(5.641)
Emp·2009			0.674	0.917
			(4.663)	(4.936)
TrendGrowth				-66.261
				(401.518)
1991-1994	20.554***	16.403***	9.882	10.328
	(2.342)	(4.485)	(7.427)	(7.977)
2001-2004	13.827***	13.630***	14.007*	14.196*
	(2.342)	(4.485)	(7.812)	(7.979)
2009-2012	15.671***	16.424***	15.503*	15.679*
	(2.342)	(4.524)	(7.859)	(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. Log employment controls are industry averages in 1991, 2001, and 2004. Includes fiscal year end indicators interacted with recovery periods to control for firm reporting differences.

Table 2.7: 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	0.88	0.10	-2.20	0.59	0.86	1.36	1.36	0.64	1.32	0.67	0.72	2.05	0.62	0.38	0.88	0.86	2.93	0.88	1.09	0.87
	(2.730)	(2.634)	(2.114)	(3.530)	(2.799)	(2.630)	(2.881)	(2.696)	(2.811)	(2.752)	(2.643)	(2.687)	(2.775)	(2.858)	(2.730)	(2.736)	(2.096)	(2.729)	(2.867)	(2.812)
Index·2012	2.68	-0.06	1.85	3.53	2.96	2.42	0.75	2.86	2.57	2.99	3.93	5.39*	2.74	3.38	2.68	2.70	1.19	2.70	2.58	2.78
	(3.227)	(2.528)	(3.078)	(4.325)	(3.204)	(3.090)	(3.348)	(3.298)	(3.223)	(3.261)	(3.478)	(2.816)	(3.225)	(3.440)	(3.227)	(3.243)	(2.955)	(3.230)	(3.234)	(3.245)
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	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.09	0.08	0.08	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. Includes fiscal year end indicators interacted with each recovery period to control for firm month reporting differences

Table 2.8: Romer and Romer Alternative Shock Measure

	Baseline VAR index
Romer and Romer Ordering	0.913***
	(0.136)
Constant	0.000
	(0.216)
Observations	19
Adjusted R-squared	0.720

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.

Figure 2.1: Seasonally Adjusted Government Consumption and Gross Investment

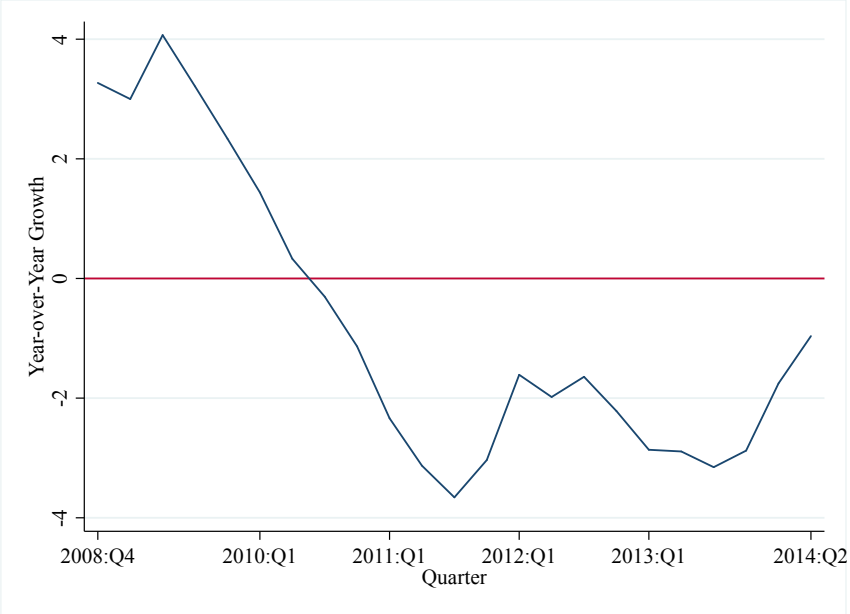

Table 2.9: Real Revenue Growth, Romer and Romer Shock Measure

	(1)	(2)	(3)	(4)
Index	1.331	1.215	1.000	0.865
	(1.325)	(1.656)	(1.585)	(2.056)
Index·2012	2.070	2.837	2.921	2.924
	(1.950)	(2.564)	(2.699)	(2.704)
Elasticity·1994		3.897**	3.612***	3.716**
		(1.399)	(1.224)	(1.422)
Elasticity·2004		-1.460	-0.790	-0.717
		(3.508)	(3.323)	(3.495)
Elasticity·2012		-1.712	-2.006	-1.915
		(5.261)	(5.144)	(5.209)
Emp·1991			-6.092***	-6.085***
			(0.927)	(0.923)
Emp·2001			0.273	0.310
			(0.718)	(0.735)
Emp·2009			-0.311	-0.284
			(0.728)	(0.739)
TrendGrowth				-97.137
				(561.647)
1991-1994	13.119	6.801	11.524*	12.146*
	(10.760)	(11.120)	(6.001)	(6.785)
2001-2004	11.579	10.265	7.233	7.850
	(12.910)	(8.397)	(14.278)	(14.255)
2009-2012	3.952	7.047	5.696	6.256
	(9.196)	(11.514)	(13.524)	(14.152)
Observations	17,723	17,723	16,480	16,480
Adjusted R-squared	0.071	0.072	0.071	0.071

*** p<0.01, ** p<0.05, * p<0.1. Industry clustered standard errors in parentheses. Includes fiscal year end indicators interacted with each recovery period to control for firm month reporting differences.

Table 2.10: Labor Productivity Growth

	(1)	(2)	(3)	(4)
Index	-0.473	0.873	1.150	1.566
	(2.294)	(2.041)	(1.900)	(1.886)
Index·2012	2.225	0.746	0.679	0.705
	(2.028)	(1.696)	(1.669)	(1.649)
Elasticity·1994		0.348	0.443	0.829
		(1.048)	(1.027)	(1.232)
Elasticity·2004		4.481*	4.641*	4.815**
		(2.379)	(2.476)	(2.136)
Elasticity·2012		-0.237	-0.224	0.109
		(2.659)	(2.685)	(2.252)
Emp·1991			0.579	0.619
			(0.483)	(0.505)
Emp·2001			3.485***	3.628***
			(1.059)	(1.078)
Emp·2009			1.456**	1.565**
			(0.661)	(0.675)
TrendGrowth				-401.238
				(277.288)
1991-1994	-0.034	3.867	-0.915	2.298
	(9.546)	(2.942)	(9.237)	(8.630)
2001-2004	6.713	3.326	-5.311	-1.943
	(4.132)	(7.250)	(4.142)	(4.257)
2009-2012	-0.671	3.534	-2.362	0.634
	(15.251)	(13.195)	(8.337)	(8.890)
Observations	15,788	15,788	15,788	15,788
Adjusted R-squared	0.018	0.020	0.023	0.024

*** p<0.01, ** p<0.05, * p<0.1. Industry clustered standard errors in parentheses. Includes fiscal year end indicators interacted with each recovery period to control for firm month reporting differences.

Table 2.11: CBO Estimates of ARRA Effects

	2009		2012	
	Low Estimate	High Estimate	Low Estimate	High Estimate
Q1	*	0.1	0.1	1.0
Q2	0.4	1.3	0.1	0.8
Q2	0.6	2.4	0.1	0.7
Q4	0.7	3.4	0.1	0.6

Source: "Estimated Impact of the American Recovery and Reinvestment Act on Employment and Economic Output from October 2012 Through December 2012", CBO, February 2013. * denotes estimate not significantly different from zero.

Figure 2.2: Industry orthogonalized responses to one standard deviation federal funds rate shock, 1971:Q1-2008:Q3. Lag length selection of two. The x-axes denote quarters. 90% asymptotic confidence intervals outlined in blue.

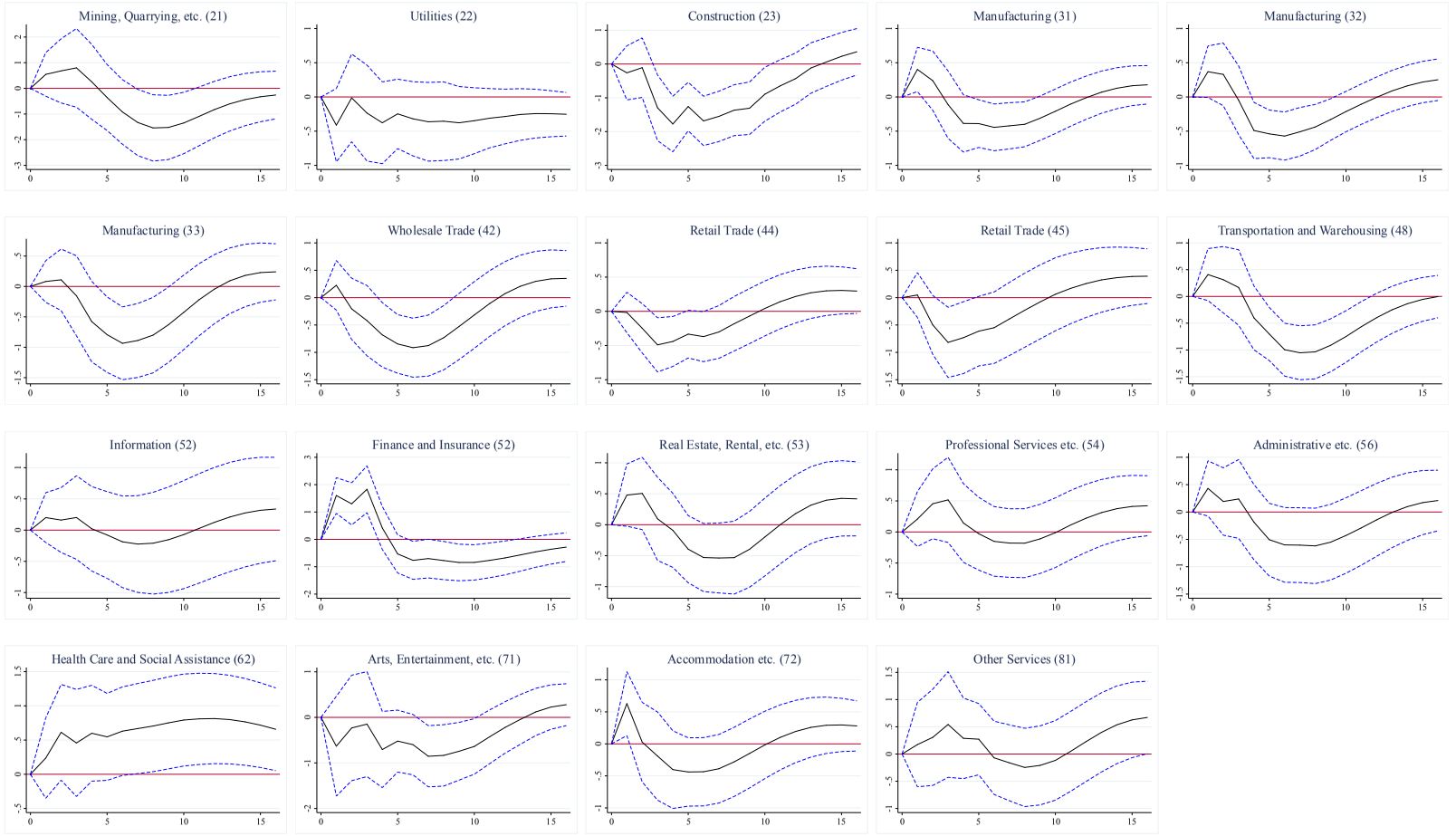

Figure 2.3: Implied Stance of Monetary Policy using GDP Growth, Accounting for Use of Generated Regressors

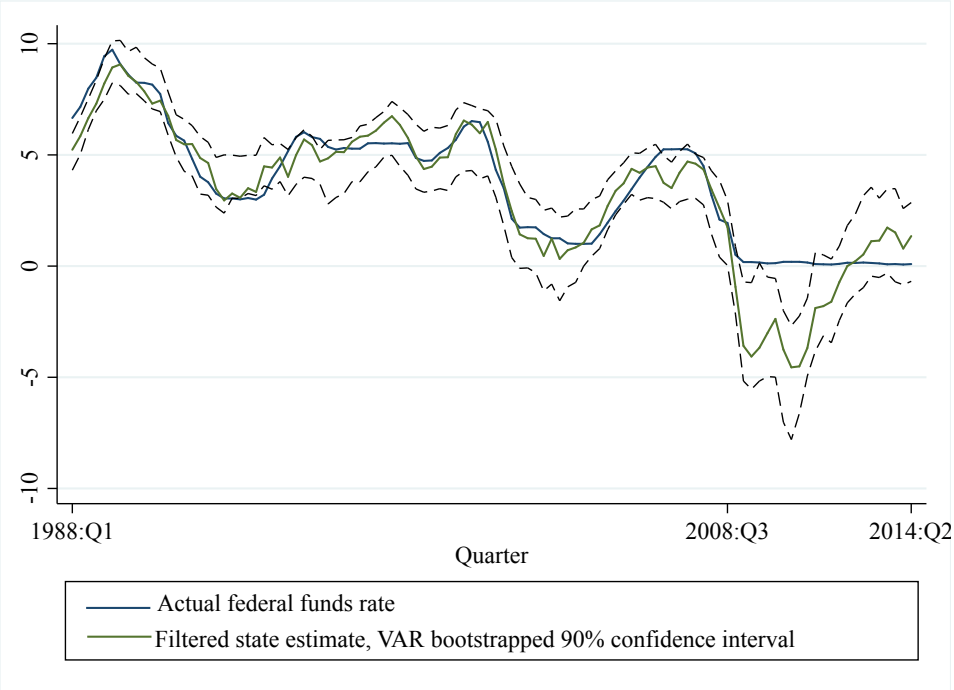

Figure 2.4: Implied Stance: Fiscal Variables, Industry Growth Rate Equations post-1971:Q1

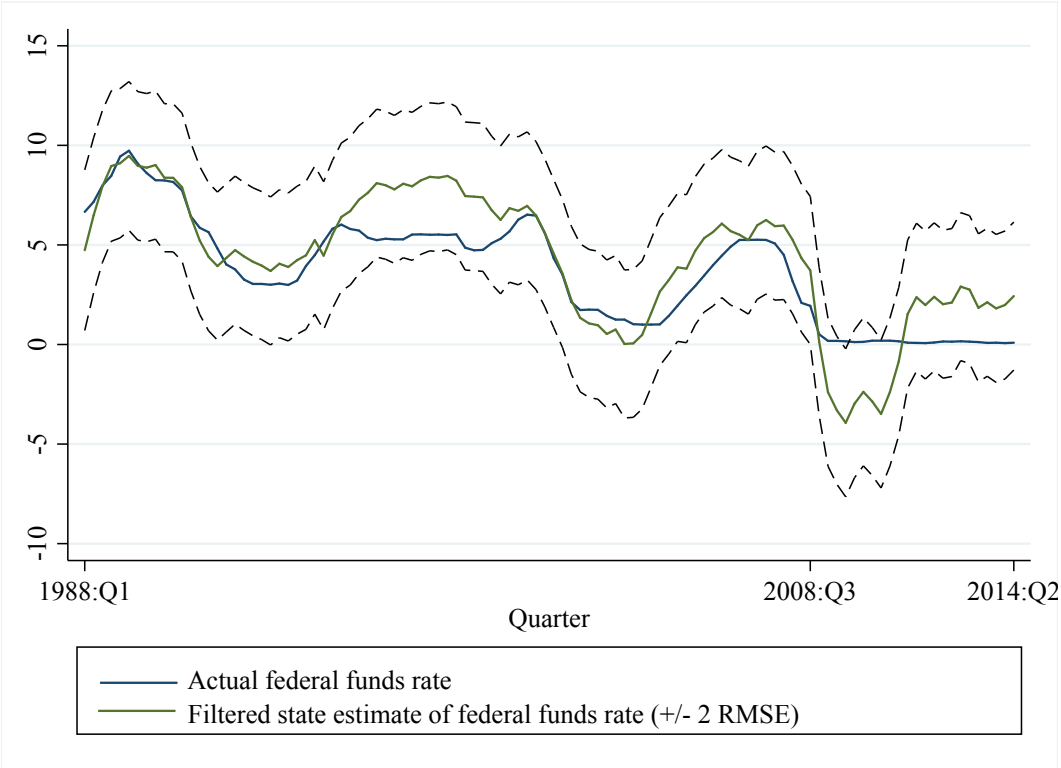

Table 2.12: OLS regressions: revenue growth and interest rate sensitivity

	(1)	(2)	(3)
	1991-1994	2001-2004	2009-2012
Index	-2.797	4.971***	3.849
	(2.129)	(1.693)	(2.550)
Constant	20.554***	13.827***	15.671***
	(2.734)	(1.768)	(2.120)
Observations	19	19	19
Adjusted R-squared	0.000	0.265	0.105

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

Figure 2.5: Implied Stance: Fiscal Variables, Industry Growth Rate Equations post-1971:Q1, Cumulative Romer and Romer Shocks with Random Walk

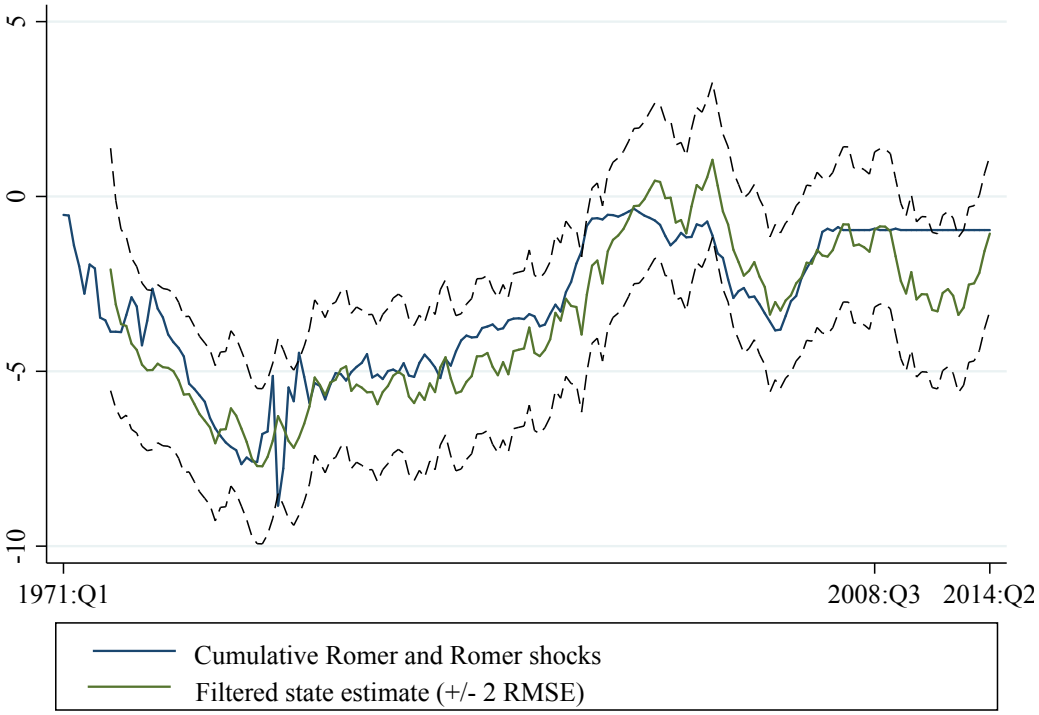

Table 2.13: Cross-correlation table: different VAR macro variable orderings

	GDP P FF	GDP FF P	FF GDP P	P FF GDP
GDP P FF	1.00			
GDP FF P	0.95	1.00		
FF GDP P	1.00	0.94	1.00	
P FF GDP	0.95	0.86	0.95	1.00

All VARs contain four lags and a constant, and are recursively identified rather than structural. GDP refers to real gross domestic product growth and real industry, P refers to price block, and FF refers to federal funds rate.

Table 2.14: Real Revenue Growth: Alternative Recursive Ordering

	(1) GDP P FF	(2) GDP FF P	(3) FF GDP P	(4) P FF GDP
Index	1.061	0.493	0.988	-0.001
	(2.667)	(2.771)	(2.766)	(2.408)
Index·2012	4.322	2.299	2.772	6.028**
	(3.026)	(3.318)	(3.253)	(2.586)
Elasticity·1994	4.464**	4.141***	4.486**	4.113**
	(1.754)	(1.295)	(1.856)	(1.856)
Elasticity·2004	0.208	-0.127	0.251	-0.231
	(3.166)	(3.004)	(3.369)	(3.397)
Elasticity·2012	2.169	0.399	1.674	2.968
	(3.563)	(4.248)	(3.976)	(3.458)
Emp·1991	-5.987***	-6.025***	-5.999***	-6.055***
	(0.947)	(0.945)	(0.943)	(0.958)
Emp·2001	0.456	0.430	0.452	0.412
	(0.703)	(0.694)	(0.695)	(0.714)
Emp·2009	0.119	0.030	0.059	0.230
	(0.615)	(0.604)	(0.614)	(0.634)
TrendGrowth	-340.814	-291.036	-322.138	-307.446
	(522.340)	(515.954)	(525.560)	(509.200)
1991-1994	12.693*	12.831*	12.501*	13.889
	(6.572)	(6.677)	(6.548)	(11.180)
2001-2004	9.005	8.759	8.370	12.079
	(13.633)	(13.801)	(13.739)	(14.636)
2009-2012	1.393	3.572	1.850	0.124
	(13.581)	(14.270)	(13.541)	(10.246)
Observations	16,480	16,480	16,480	16,480
Adjusted R-squared	0.071	0.070	0.071	0.071

*** p<0.01, ** p<0.05, * p<0.1. Industry standard errors clustered in parentheses. Includes fiscal year end indicators interacted with each recovery period to control for firm month reporting differences. The indices are created using recursively identified VARs. GDP refers to real gross domestic product growth and real industry revenes, P refers to price block, and FF refers to federal funds rate.

Table 2.15: 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

Correlations are from indices resulting from SVARs from equation (1.4).

Table 2.16: Real Revenue Growth: Alternative Lag Lengths

	(1) Baseline	(2) 2 Lags	(3) 3 Lags	(4) 5 Lags
Index	0.878	0.365	0.927	-0.406
	(2.730)	(2.436)	(2.862)	(2.448)
Index·2012	2.685	5.634**	3.602	0.958
	(3.227)	(2.450)	(3.028)	(2.906)
Elasticity·1994	4.432**	4.191**	4.376**	4.016**
	(1.813)	(1.474)	(1.679)	(1.405)
Elasticity·2004	0.193	-0.121	0.133	-0.375
	(3.369)	(3.066)	(3.233)	(3.382)
Elasticity·2012	1.545	1.721	1.542	-0.027
	(4.042)	(3.613)	(4.259)	(4.901)
Emp·1991	-6.004***	-6.027***	-6.007***	-6.085***
	(0.944)	(0.948)	(0.925)	(0.939)
Emp·2001	0.449	0.430	0.443	0.373
	(0.695)	(0.712)	(0.704)	(0.717)
Emp·2009	0.056	0.208	0.089	-0.078
	(0.615)	(0.630)	(0.643)	(0.669)
TrendGrowth	-319.437	-317.758	-322.255	-239.361
	(528.768)	(509.288)	(519.209)	(606.796)
1991-1994	12.552*	13.831	12.616*	12.794*
	(6.531)	(10.944)	(6.394)	(6.691)
2001-2004	8.464	11.951	10.592	8.775
	(13.712)	(14.493)	(6.110)	(13.643)
2009-2012	1.969	1.790	1.744	3.971
	(13.554)	(10.711)	(13.589)	(14.421)
Observations	16,480	16,480	16,480	16,480
Adjusted R-squared	0.070	0.071	0.071	0.070

*** p<0.01, ** p<0.05, * p<0.1. Industry standard errors clustered in parentheses. Includes fiscal year end indicators interacted with each recovery period to control for firm month reporting differences.

Table 2.17: Real Revenue Growth: Two Year Growth, Year Following Trough

	(1)	(2)	(3)	(4)
Index	0.799	1.367	0.814	0.974
	(1.798)	(1.776)	(1.522)	(1.736)
Index·2012	0.048	0.294	1.017	1.030
	(1.628)	(1.970)	(1.939)	(1.939)
Elasticity·1994		5.184***	4.422***	4.580***
		(1.184)	(1.084)	(1.272)
Elasticity·2004		-1.719	-2.127	-2.058
		(3.066)	(2.751)	(2.662)
Elasticity·2012		1.400	0.778	0.919
		(3.129)	(3.044)	(2.960)
Emp·1992			-4.609***	-4.589***
			(0.717)	(0.718)
Emp·2002			0.068	0.125
			(0.685)	(0.680)
Emp·2010			-0.453	-0.412
			(0.383)	(0.361)
TrendGrowth				-157.675
				(353.311)
1992-1994	12.564	2.795	9.083	10.042
	(14.174)	(5.411)	(14.171)	(15.104)
2002-2004	11.015**	13.955*	16.276**	17.351*
	(4.859)	(6.955)	(7.381)	(8.379)
2010-2012	5.745	3.293	7.485	8.392
	(10.676)	(12.060)	(13.104)	(13.514)
Observations	19,075	19,075	17,555	17,555
Adjusted R-squared	0.085	0.087	0.079	0.079

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors clustered at NAIC 2 digit level in parentheses. Includes fiscal year end indicators interacted with each recovery period to control for firm month reporting differences. Log employment controls are firm-level in 1992, 2012, and 2010.

Table 2.18: Examining 2011-2013 Growth

	(1)	(2)	(3)	(4)
Index	0.799	1.367	0.814	0.815
	(1.798)	(1.776)	(1.522)	(1.710)
Index2013	-0.539	0.908	1.235	1.234
	(2.026)	(2.276)	(1.857)	(1.866)
Elasticity·1994		5.184***	4.422***	4.423***
		(1.184)	(1.084)	(1.307)
Elasticity·2004		-1.719	-2.127	-2.127
		(3.067)	(2.751)	(2.746)
Elasticity·2013		3.666	3.602	3.602
		(2.599)	(2.123)	(2.149)
Emp·1991			-4.609***	-4.608***
			(0.717)	(0.715)
Emp·2001			0.068	0.069
			(0.685)	(0.684)
Emp·2011			-2.159***	-2.159***
			(0.710)	(0.681)
TrendGrowth				-0.953
				(312.889)
1992-1994	10.429*	2.795	11.884	11.892*
	(5.764)	(5.411)	(7.182)	(6.363)
2002-2004	-0.097	4.068	21.100	21.107
	(5.112)	(7.686)	(17.279)	(17.275)
2011-2013	-1.709	-0.670	10.929	10.936
	(8.233)	(6.995)	(9.279)	(9.332)
Observations	16,642	16,642	15,312	15,312
Adjusted R-squared	0.091	0.094	0.086	0.086

*** p<0.01, ** p<0.05, * p<0.1. Industry clustered standard errors in parentheses. Includes fiscal year end indicators interacted with each recovery period to control for firm month reporting differences

Table 2.19: Examining 2011-2013 Growth, Controlling for Tax Sensitivity

	(1)	(2)	(3)	(4)
Index	-0.050	-1.706	0.572	-1.007
	(1.809)	(3.184)	(2.755)	(3.315)
Index2013	0.310	10.199***	1.490	9.406***
	(2.394)	(3.503)	(2.450)	(2.714)
1992-1994	31.767***	31.290***	24.037*	25.606***
	(6.284)	(6.943)	(11.599)	(6.654)
2002-2004	24.151	17.020	5.446	18.308
	(18.903)	(19.339)	(9.465)	(12.773)
2011-2013	22.675**	34.486***	6.065	30.683***
	(10.497)	(10.444)	(5.835)	(10.003)
Tax·1994		0.528		1.766
		(7.351)		(6.813)
Tax·2004		5.689		4.952
		(4.038)		(6.511)
Tax·2011		-18.990***		-14.250***
		(2.825)		(3.136)
Elasticity·1994			4.133*	3.848**
			(1.983)	(1.775)
Elasticity·2004			0.060	0.685
			(3.582)	(4.197)
Elasticity·2013			3.617	3.807**
			(2.209)	(1.323)
Emp·1991			-6.036***	-6.104***
			(0.936)	(0.961)
Emp·2001			0.343	0.322
			(0.713)	(0.711)
Emp·2013			-2.153***	-1.882**
			(0.709)	(0.662)
TrendGrowth			-20.905	-54.387
			(493.482)	(544.397)
Observations	15,610	15,610	14,509	14,509
Adjusted R-squared	0.064	0.066	0.065	0.066

*** p<0.01, ** p<0.05, * p<0.1. Industry clustered standard errors in parentheses. Includes fiscal year end indicators interacted with each recovery period to control for firm month reporting differences

Table 2.20: Real Revenue Growth and Multi-factor Productivity Growth

	(1)	(2)	(3)	(4)
Index	-0.050	-0.050	0.878	0.931
	(1.809)	(1.809)	(2.730)	(2.719)
Index·2012	2.302	2.059	2.685	1.563
	(3.745)	(3.775)	(3.227)	(3.477)
Elasticity·1994			4.432**	4.484**
			(1.813)	(1.792)
Elasticity·2004			0.193	0.216
			(3.369)	(3.335)
Elasticity·2012			1.545	0.161
			(4.042)	(4.764)
Emp·1991			-6.004***	-5.999***
			(0.944)	(0.946)
Emp·2001			0.449	0.467
			(0.695)	(0.703)
Emp·2009			0.056	0.136
			(0.615)	(0.625)
TrendGrowth			-319.437	-370.534
			(528.768)	(549.309)
1991-1994	12.641*	12.641*	12.552*	12.891*
	(6.264)	(6.265)	(6.531)	(6.523)
2001-2004	7.881	8.871	8.464	10.881*
	(12.206)	(12.341)	(13.712)	(5.980)
2009-2012	4.008	2.976	1.969	4.320
	(11.679)	(11.566)	(13.554)	(16.273)
MFPgrowth·2012		11.792		14.630
		(12.922)		(15.587)
Observations	17,723	17,723	16,480	16,480
Adjusted R-squared	0.070	0.071	0.070	0.071

*** p<0.01, ** p<0.05, * p<0.1. Industry clustered standard errors in parentheses. Includes fiscal year end indicators interacted with each recovery period to control for firm month reporting differences.

State-Space Representation of SVAR Results in Structural Form

Consider a SVAR system with the variables GDP growth, commodity price growth, PCE inflation growth, the federal funds rate, and industry revenues. Let X_t equal a vector W_t concatenated with the 19 industry revenue growth series, g_{jt}, for $j = (1, 19)$, where W_t is the vector $(gdpgrowth_t, comgrowth_t, pcegrowth_t)'$. Then a system containing GDP growth, commodity price growth, PCE inflation, and industries revenue growth rates with 4 lags,

$$Z_t = \hat{c} + \hat{B}(L)W_t + \hat{\Gamma}(L)Z_{t-1} + u_{5t}$$

$$X_t = \hat{C} + \hat{F}(L)W_t + \hat{\Lambda}(L)Z_{t-1} + \zeta_t$$

can be written as follows:
State equations

$$\begin{bmatrix} z_t \\ z_{t-1} \\ z_{t-2} \\ z_{t-3} \\ z_{t-4} \end{bmatrix} = \begin{bmatrix} \hat{c}_z \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} \hat{b}_{12} & \hat{b}_{13} & \hat{b}_{14} & \hat{b}_{15} & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} z_{t-1} \\ z_{t-2} \\ z_{t-3} \\ z_{t-4} \\ z_{t-5} \end{bmatrix} + \begin{bmatrix} \hat{B}_{11} & \hat{B}_{12} & \hat{B}_{13} & \hat{B}_{14} & \hat{B}_{15} \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} W_t \\ W_{t-1} \\ W_{t-2} \\ W_{t-3} \\ W_{t-4} \end{bmatrix} + \begin{bmatrix} u_{z,t} \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Measurement equations, macro variables

$$W_t = \begin{bmatrix} y_t \\ comgrowth_t \\ \pi_t \end{bmatrix} = \begin{bmatrix} \hat{c}_y \\ \hat{c}_{com} \\ \hat{c}_\pi \end{bmatrix} + \begin{bmatrix} \hat{d}_{11} & \hat{d}_{12} & \hat{d}_{13} & \hat{d}_{14} \\ \hat{d}_{22} & \hat{d}_{22} & \hat{d}_{23} & \hat{d}_{24} \\ \hat{d}_{32} & \hat{d}_{32} & \hat{d}_{33} & \hat{d}_{34} \end{bmatrix} \begin{bmatrix} z_{t-1} \\ z_{t-2} \\ z_{t-3} \\ z_{t-4} \end{bmatrix} + \begin{bmatrix} \hat{D}_{11} & \hat{D}_{12} & \hat{D}_{13} & \hat{D}_{14} & \hat{D}_{15} \\ \hat{D}_{21} & \hat{D}_{22} & \hat{D}_{23} & \hat{D}_{24} & \hat{D}_{25} \\ \hat{D}_{31} & \hat{D}_{32} & \hat{D}_{33} & \hat{D}_{34} & \hat{D}_{35} \end{bmatrix} \begin{bmatrix} W_t \\ W_{t-1} \\ W_{t-2} \\ W_{t-3} \\ W_{t-4} \end{bmatrix} + \begin{bmatrix} u_{y,t} \\ u_{com,t} \\ u_{\pi,t} \end{bmatrix}$$

Measurement equations, industry revenues

$$IndustryRevenues_{j,t} = \hat{c}_j + \begin{bmatrix} \hat{e}_{j,12} & \hat{e}_{j,13} & \hat{e}_{j,14} & \hat{e}_{j,15} \end{bmatrix} \begin{bmatrix} z_{t-1} \\ z_{t-2} \\ z_{t-3} \\ z_{t-4} \end{bmatrix} + \begin{bmatrix} \hat{E}_{j,0} & \hat{E}_{j,1} & \hat{E}_{j,2} & \hat{E}_{j,3} & \hat{E}_{j,4} \end{bmatrix} \begin{bmatrix} W_t \\ W_{t-1} \\ W_{t-2} \\ W_{t-3} \\ W_{t-4} \end{bmatrix}$$

$$+ \begin{bmatrix} \hat{\rho}_{j,1} & \hat{\rho}_{j,2} & \hat{\rho}_{j,3} & \hat{\rho}_{j,4} \end{bmatrix} \begin{bmatrix} IndustryRev_{j,t-1} \\ IndustryRev_{j,t-2} \\ IndustryRev_{j,t-3} \\ IndustryRev_{j,t-4} \end{bmatrix} + u_{j,t}$$

All parameters and variables from the 1988:Q1- 2008:Q3 structural VARs are inputed. I then use the Kalman filter on the system with data from 1988:Q1- 2014:Q2 to recover an estimate of the state z_t, the federal funds rate, at each quarter t.

Chapter 3

Reserve accumulation and domestic investment

3.1 Introduction

Beginning in the 1990s, many emerging market countries began a policy of foreign exchange reserve accumulation. A vast literature has examined the merits and motivations for this policy change. Real exchange rate undervaluation is associated with economic development, which has led to a line of research tying reserve accumulation to export-led growth [Rodrik, 2007, Dooley et al., 2003]. On the other hand, a large literature has emphasized the precautionary savings motive of reserve accumulation, whereby countries insulate themselves from financial shocks [Aizenman and Lee, 2007, Aizenman and Lee, 2008].

This chapter explores a henceforth relatively under-researched aspect of reserve

accumulation. By definition, reserve accumulation implies that savings are sent abroad. All else equal, [Reinhart et al., 2016] note that this implies that it is possible for this savings outflow to decrease domestic investment through a reduction in domestically available funds, which the authors label "crowding out redefined". More specifically, this hypothesis can be seen through following two relationships:

$$CA + KA + RA = 0 \tag{3.1}$$

$$CA := S - I \tag{3.2}$$

The current account, CA, plus the capital account, KA, are equal so long as reserve accumulation is zero. However, if a country accumulates foreign reserves, it is then necessarily the case that there is an official capital outflow. If these relationships hold such that total savings and total investment do not change in response to reserve accumulation, it must be the case that reserve accumulation crowds out, or reduces, private investment. [Reinhart et al., 2016] examine a VAR of Reserves/GDP and gross fixed capital formation, using group means of several selected Asian countries, from 1970-2014. They find that within three years, investment exhibits a significantly negative decrease in response to a reserve shock.

This chapter further tests [Reinhart et al., 2016]'s hypothesis using a much larger set of countries. Furthermore, we introduce a separate methodology that allows many more variables to be controlled for. In contrast to [Reinhart et al., 2016], we find the reserve accumulation is not closely associated with decreases in investment out

investment. Our results suggest that reserve accumulation has only a very small effect on private investment, and is correlated with contemporaneous increases in growth *increases* in investment within one year. Thus, we do not find that "crowding out redefined" seems to hold more broadly than within the few Asian countries studied by [Reinhart et al., 2016].

Our method of investigation is closely related to papers in the literature which have examined the growth of private gross fixed capital formation, a proxy for private domestic investment. [Joyce and Nabar, 2009] research the relationship between financial crises, sudden stops, and investment collapses in emerging markets, finding strong negative effects. [Cavallo and Daude, 2011] present evidence that public investment crowds out private investment. [Inklaar and Yang, 2012] examine the relationship between cultural values and investment, showing that private investment decreases more following financial crises in countries ranked highly in uncertainty avoidance. We follow [Joyce and Nabar, 2009, Cavallo and Daude, 2011, Inklaar and Yang, 2012] in the use of fixed effect and GMM dynamic panel models explaining private gross fixed capital formation as a proxy for domestic investment. In other related work, [Steiner, 2009] and [Chitu, 2016] provide evidence that reserve accumulation can results in inflation if it is unsterilized, or allows greater public borrowing.

3.2 Methodology

This chapter focuses on investment, which is known to be a highly persistent variable. In addition, controlling for lagged investment dynamics helps to control for many other serially correlated factors that could effect investment. We thus estimate a dynamic panel data model. Note that this tests "crowding out redefined" differently than [Reinhart et al., 2016], who use a VAR framework.[1] As in relevant literature examining the determinants of investment [Joyce and Nabar, 2009, Cavallo and Daude, 2011, Inklaar and Yang, 2012], the following model of Investment/GDP is estimated for each country i during year t.

$$\left(\frac{I_{i,t}}{GDP_{i,t}}\right) = \rho\left(\frac{I_{i,t-1}}{GDP_{i,t-1}}\right) + \beta R_{i,t} + \Gamma X_{i,t} + \delta_t + \mu_i + \epsilon_{i,t} \tag{3.3}$$

The main estimated coefficient of interest, β, measures the correlation between Reserves/GDP and Investment/GDP. Aside from reserve accumulation, it is important to control for other macro factors, such as lagged GDP growth, in the vector $X_{i,t}$. Time fixed effects (δ_t) are important in order to control for global shocks. Finally, μ_i denotes country fixed effects, as countries can differ in their steady state levels of investment. In evidence of a causal interpretation of β, we show that estimates hold regardless of the specification or control variables included in Equation 3.3.

[1] Our approach has the advantage of controlling for factors that may be omitted in a VAR framework. It is also a more standard approach for examining investment growth. We view our approach as complementary rather than superior to a VAR framework.

As stated, reserve accumulation implies an official capital outflow. All else equal, this implies lower domestic investment, as savings are funneled abroad. We postulate that if reserve accumulation does in fact crowd out private investment, we should expect to see that $\hat{\beta} < 0$ under exogeneity of the policy intervention. We also experiment with different lags of Reserves/GDP in order rule out lagged effects, since reserve accumulation can depreciate domestic currencies, causing a lagged effect on export growth. In justification for the exogeneity of reserves in Equation 3.3, [Reinhart et al., 2016] show that investment does not Granger-cause reserve accumulation[2].

Fixed effect and ols estimates are known to be biased in the presence of lagged dependent variables [Nickell, 1981]. The error term in Equation 3.3 is by construction correlated with the lagged dependent variable, as y_{t-1} is a function of the contemporaneous error term. However, it is important to control for time-invariant country effects, as countries can differ substantially in their average investment levels.

We thus use system GMM (Blundell-Bond) to further identify equation 3.3[3]. This approach corrects for the fact that lagged dependent variables are correlated with fixed effect error terms by using lagged levels and lagged changes of the dependent variable as instruments. In practice, we find that difference GMM (Arellano-Bond) performs poorly due to weak instruments. We thus present both fixed effects and system GMM estimations. In all cases, we report one-step GMM estimates; two-step estimates give similar results.

[2]Note that this does provide evidence against the endogeneity of reserve accumulation to investment growth, but cannot rule it out.

[3]We use the Stata package xtabond2 developed by [Roodman, 2006]

Formally, we use the following moment condition, for t at lag length j, in estimating difference GMM (the Arellano-Bond estimator).

$$E\left[y_{i,t-j}\epsilon_{i,t}\right] = 0 \tag{3.4}$$

This expectation requires that the errors are not serially correlated. We find evidence that this assumption is valid. However, the instruments generated via this moment condition are too weak. As investment follows close to a random walk, this is not unexpected, as the forecasting power of lagged levels of investment is not predictive. This results in estimates fluctuating wildly depending on lag length specification choices. The system GMM estimator, whereby lagged changes in the dependent variable are used as instruments, is meant to surmount this problem. This estimator minimizes the following moment condition for each t at lag length j,

$$E\left[\Delta y_{i,t-j}\epsilon_{i,t}\right] = 0 \tag{3.5}$$

In order for this estimation to be valid, [Blundell and Bond, 1998] show that the dependent variables must not be systematically further away from steady state levels at the beginning of the sample. Within this chapter's context, this may not be the case, given the rapid development and convergence of lower income nations to higher income nations since the 1970s. We would perhaps expect investment ratios to growth faster in the initially less developed countries.[4] We thus present fixed effects estimates

[4]Figure 3.1 charts Investment/GDP for selected countries, revealing that Honduras, for example, does seem to have had steady increases in investment levels.

as a complement to system GMM estimations. Although the fixed effects estimates are biased, the average length of each country panel is 20 years. Nickell's bias is of the order $1/T$, meaning that the bias should not be so drastic so as to render these estimates useless.

The difference and system GMM estimators are notoriously sensitive to mild changes in specification. There exists little theoretical guidance on correct lag length selection, necessary instrument count, or the most efficient way to limit the proliferation of instruments, while still avoiding overfitting. In particular, the problem of too many instruments can cause estimates using GMM to vastly underestimate uncertainty [Roodman, 2009]. This also provides a good reason to present both fixed effects and GMM estimates in order to show that GMM estimates are within a plausible range of the biased fixed effects estimates.

In order to prevent overfitting, [Roodman, 2009] presents two suggestions. The first is to limit lag count in the GMM instrument sets. In our case, the time dimension of our panel is large enough such that even when limiting lag lengths, the number of instruments exceeds the number of countries during estimation. [Roodman, 2009] gives this as a rule of thumb for when the instrument count is too large. We thus follow [Roodman, 2009] 's second suggestion, and collapse the GMM instrument set such that there is only a single moment for each lag, rather than for each lag length and each time period. Furthermore, we experiment with collapsed instrument sets and limits on instrument lag lengths. The collapsed instrument set is sufficiently small such that we are able to use all other covariates in Equation 3.3 as IV style instruments. We thus

take all other variables in Equation 3.3 as exogenous.

In all results, we report a number of statistics to show that the GMM estimates are well specified. The instrument count is reported to show that the results are not due to overfitting, as the instrument count is always below the number of countries. The Arellano-Bond test for AR 1 autocorrelation in differences always reject the null of no autocorrelation, as should be expected[5]. The AR2 autocorrelation tests in differences is never rejected at the 10% level. No second order autocorrelation in first differences implies that there is no first order serial correlation in levels, as is required for the use of lags 2 and above as instruments. Finally, the Hansen statistic is reported, testing against the null of exogeneity of the instruments, and is also never rejected.

3.3 Data

For our main variables of interest, we use annual data from 1970-2010 on gross fixed capital formation and reserves, both scaled by GDP. Other control variables consist of data from the IMF's Global Financial Statistics, Balance of Payments Statistics Yearbooks, and the World Bank's World Development Indicators. We augment these sources with financial crisis indicators from [Laeven and Valencia, 2008] and [Reinhart and Rogoff, 2010]. We list a full set of sources and greater description of variables in Ancillary Materials.

Figure 3.2 charts Reserves/GDP for selected countries. Thailand is character-

[5]Assume that first-differenced residuals are denoted by $\Delta\epsilon_{it}$. Then $\Delta\epsilon_{it}$ and $\Delta\epsilon_{i,t-1}$ are mathematically related through $\epsilon_{i,t-1}$.

ized by an upward trend in reserve accumulation. As noted by [Reinhart et al., 2016], this country is representative of the Asian economies [Reinhart et al., 2016] focus on to highlight the mechanism of "crowding out redefined". In contrast, the reserve accumulation Brazil, Honduras, and the Philippines is more cyclically generated. However, it is of note that all else equal and controlling for GDP dynamics, it should be the case that private investment is crowded out regardless of whether reserves are structurally or cyclically purchased as long as there is some variation across business cycles within each country. Table 3.7 lists the countries in our sample.

Table 3.1 presents summary statistics for the sample. As is common in the literature, we use gross fixed capital formation as a proxy for domestic investment. On average, this component represents approximately 15% of GDP, and is typically very business cycle sensitive. Relatively high mean GDP growth and inflation rates reflect the fact that the sample is composed of many emerging economies and less developed countries.

3.4 Findings

In order to get a sense of sensible autoregressive coefficients, Table 3.2 presents a variety of basic specifications of Equation 3.3 with no control variables. Columns (1) and (2), which present biased OLS and fixed effect estimates, signifies that a correctly estimated AR coefficient should lie somewhere within the realm of 0.7 to 0.93[6]. Column

[6][Bond, 2002] states that OLS and fixed effect AR coefficients in dynamic panel models are biased in opposite directions, and can thus be used for a guide in using more advanced estimators.

(3) presents fixed effects estimates for countries with greater than 30 years of data. As the bias of fixed effect estimates decreases in T, we observe that the AR coefficient (ρ) is estimated to be larger, as predicted. Column (2) thus likely provides an extreme lower bound on ρ. Column (4) shows that including time fixed effects does not seem to affect ρ. Columns (5)-(7) present various system GMM specifications. Using GMM, ρ is estimated to be equal to 1 with high consistency.

A second important coefficient in Table 3.2 is β, the correlation between reserves and investment. It is of note that in all but one specification, reserves do not seem to have a contemporaneous effect on investment. We will see, however, that this coefficient is in fact estimated to be negative in a variety of specifications.

Table 3.3 replicates fixed effect estimates and GMM estimates while adding control variables that have been noted to be important determinants of investment in the literature [Joyce and Nabar, 2009, Cavallo and Daude, 2011, Inklaar and Yang, 2012]. Of note, foreign direct investment is a highly significant determinant of domestic investment in 3 of 4 specifications. In contrast to the rest of the literature, inflation, trade openness, and interest payments do not seem to be correlated with investment. We do see, however, that reserve accumulation is associated with lower investment in 7 of the 10 specifications. Although the controls are not significant, their inclusion suggests that contemporaneous increases in reserves do have small effects on investment. Interpreting the coefficients in regressions where reserves are a significant predictor of investment, a 1% increase in reserves/GDP is associated with a 0.07-0.11% decrease in investment.

Table 3.4 controls for financial crises, as reserves can drain quickly during crisis

events and bias the relationship. The coefficient β on reserves stays within a similar range whether or not crises are controlled for. It is of note that only debt crises are highly associated with investment falls, reflecting the systemic nature of those events.

Table 3.5 changes the specification of Equation 3.3. Instead of assuming that reserves have contemporaneous effects on investment, we test lagged reserves. This specification more closely reflects the tests of [Reinhart et al., 2016], who find that "crowding out redefined" occurs with a lag. In fact, Table 3.5 shows that the lagged accumulation of reserves is *positively* associated with investment.[7] Table 3.6 includes both contemporaneous and lagged reserves. GMM specifications are not presented as they vary too widely to be useful due to weak instruments. In Table 3.6, we also see that the effect of reserve increases is mean reverting: within a year, investment increases subsequent to the initial decrease.

We briefly consider a number of explanations for this finding. Reserve accumulation depreciates the domestic currency [Fatum and M Hutchison, 2003]. As long as the effect of cheaper exports dominates the effect of more expensive intermediate imports, this causes an increase in exports. An anticipated or realized increase in exports could thus lead to higher investment, as aggregate demand increases due to higher utilization of unemployed resources or under-employed sectors [Dooley et al., 2003]. However, controlling for trade as a percent of GDP did not change the estimates. Furthermore, Table 3.8 shows that real exchange rates are not found to be lower following reserve accumulation.[8] This channel could be further tested with more granular data

[7] In ancillary materials, it is shown that this holds when lagging all control variables as well.
[8] GMM specifications suffer from the poor instruments problem, and so are not presented.

and/or a VAR framework to examine longer lagged effects of reserve accumulation.

With perfect capital mobility, any increase in foreign reserves is balanced by an increase in foreign inflows. We would then not observe effects of reserve accumulation on investment, as savings available for domestic investment would be unchanged In fact, [Alberola et al., 2016] find that the accumulation of reserves are associated is associated with increased capital flows. However, they do not explicitly test for whether reserve outflows are balanced by capital inflows, as that is not the focus of their chapter. This presents another avenue for further research to reconcile this chapter's findings with [Reinhart et al., 2016].

3.5 Conclusion

In this chapter we further investigate the hypothesis of [Reinhart et al., 2016] that reserve accumulation can crowd out domestic investment. Consistent with [Reinhart et al., 2016], we find some weak evidence that reserve accumulation is negatively associated with domestic investment. However, unlike [Reinhart et al., 2016], we document that this correlation is immediate, and that it reverses within a year. In fact, we find evidence suggesting that this negative correlation is balanced by an even greater increase in investment in the year following a change in a reserves relative to GDP in some specifications. Surprisingly, this correlation is significant more often than the immediate negative correlation we find in support of [Reinhart et al., 2016]'s hypothesis. Notably, our sample omits many of the countries [Reinhart et al., 2016] use to support

their hypothesis, but does shed light on the broader implications of "crowding out redefined." This chapter's approach could be further expanded to include panel VARs,[9] and test the channels through which reserve accumulation can affect investment.

While our sample consists of mostly emerging markets and less developed countries, our results also have ramifications for wealthier nations. In order to fulfill its mandate of price stability, the European Central Bank has implemented so-called quantitative easing, or large scale asset purchases However, expansionary policy was largely implemented in spite of the strength the German economy, the Eurozone's largest member. Program rules stipulate that national central banks cannot buy bonds with yields that could result in future central bank losses, which are likely for German Bunds as their yields have at times been negative. Faced with asymmetric policy needs in Eurozone countries, it may make sense for NCBs such as the Bundesbank to buy bonds from other nations, given that they can no longer implement purchases on their own bonds, and given that the ECB's mandate for 2% medium term inflation needs to be fulfilled. In a sense, this would correspond to accumulation of foreign reserves, albeit using the Eurozone's common currency. Our estimates suggest that implementing such a policy would not substantially hamper domestic investment.

Table 3.1: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Median
Private GFCF	1222	15.97	7.55	.05	125.21	15.62
Reserves (% of GDP)	1222	1.8	4.35	-17.13	48.3	1.07
RGDP growth	1218	3.8	5.4	-38.74	29.64	4.28
Inflation	1218	53.64	354.16	-29.17	6261.24	8.55

[9]This setup would be preferable for testing lagged effects, whereby investment is affected years after a currency depreciation.

Figure 3.1: Gross Fixed Capital Formation/GDP: Selected Countries

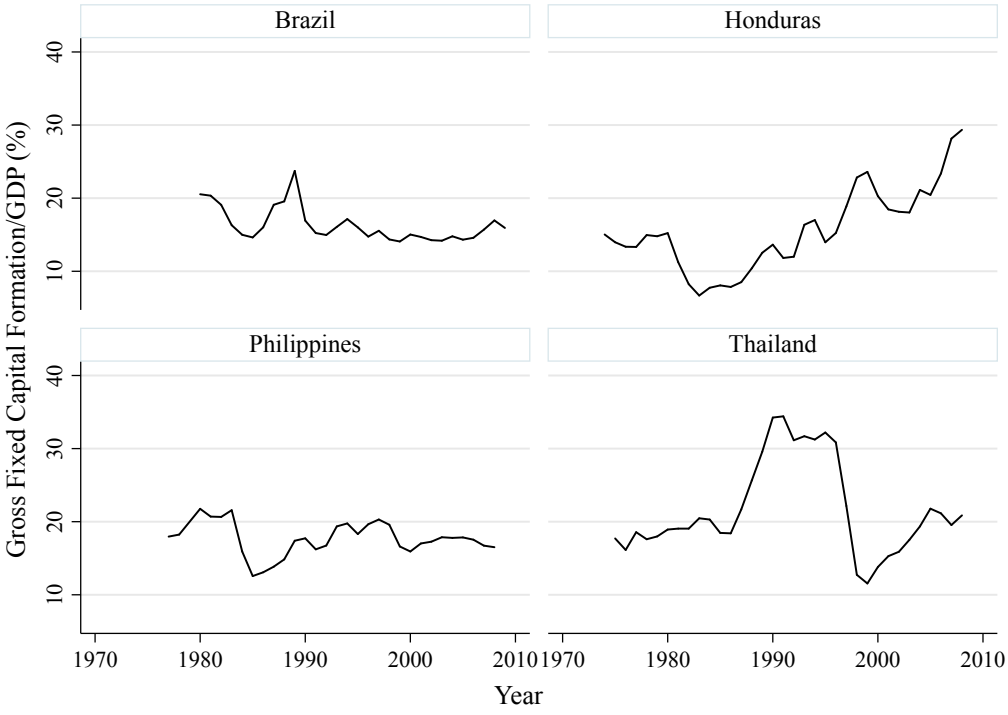

Figure 3.2: Reserves/GDP: Selected Countries

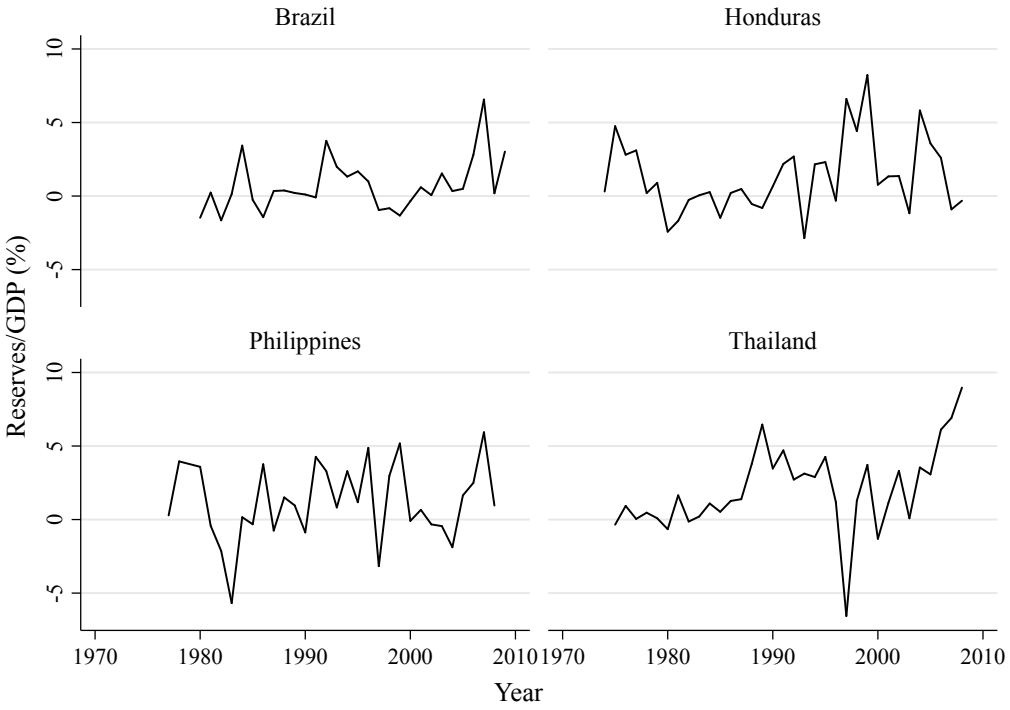

Table 3.2: Basic Regressions: Gross Fixed Capital Formation and Reserves

	(1) OLS	(2) FE	(3) FE, T > 30	(4) FE	(5) GMM	(6) GMM	(7) GMM
Lagged Private GFCF	0.93***	0.75***	0.80***	0.74***	1.00***	0.99***	0.99***
	(0.05)	(0.02)	(0.04)	(0.02)	(0.05)	(0.05)	(0.05)
Reserves/GDP	-0.00	-0.01	0.05	-0.02	-0.05	-0.05	-0.07*
	(0.03)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)
Constant	1.35**	4.20***	3.13***	3.45***	0.21	0.42	1.18
	(0.65)	(0.41)	(0.68)	(0.41)	(0.80)	(0.79)	(0.77)
Observations	1,158	1,158	658	1,158	1,158	1,158	1,158
R-squared	0.70	0.49	0.63	0.52			
Number of countryid		59	22	59	59	59	59
Number of Instruments					7	41	45
Hansen test					0.296	0.537	0.658
AR1 test p-value					0.0581	0.0611	0.0491
AR2 test p-value					0.111	0.113	0.107

*** p<0.01, ** p<0.05, * p<0.1. Industry clustered standard errors in parentheses. OLS, FE, and GMM denotes ordinary least squares, fixed effects, and system GMM respectively. Column (3) includes countries only with 30 or more yearly observations. Column (4) includes year fixed effects. Columns (5) through (7) are collapsed and restrict instrument lengths to 2-5 lags, 2-unlimited lags, and 2-5 lags respectively. Column (7) includes year fixed effects.

Table 3.3: Gross Fixed Capital Formation and Reserves, With Controls

	(1) FE	(2) FE	(3) FE	(4) FE	(5) FE	(6) GMM	(7) GMM	(8) GMM	(9) GMM	(10) GMM
Lagged Private GFCF	0.73***	0.73***	0.67***	0.59***	0.67***	0.98***	0.98***	0.94***	0.78***	0.97***
	(0.02)	(0.02)	(0.06)	(0.10)	(0.05)	(0.05)	(0.05)	(0.09)	(0.15)	(0.07)
Reserves/GDP	-0.02	-0.02	-0.07*	-0.06	-0.09*	-0.07*	-0.07*	-0.09**	-0.09***	-0.11**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.03)	(0.03)	(0.04)
Lagged RGDP Growth	0.08*	0.09**	0.09**	0.08*	0.05	0.06	0.06	0.06	0.05	0.01
	(0.05)	(0.04)	(0.04)	(0.04)	(0.06)	(0.04)	(0.04)	(0.04)	(0.03)	(0.05)
Inflation		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00
		(0.00)	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Trade (% of GDP)			0.06*	0.02*	0.02			0.02	0.01	0.00
			(0.03)	(0.01)	(0.01)			(0.01)	(0.01)	(0.00)
FDI (%GDP)				0.24***	0.16*				0.21***	0.06
				(0.07)	(0.10)				(0.08)	(0.05)
Interest Payments (% GNI)					0.06					0.02
					(0.19)					(0.16)
Constant	3.08***	3.00***	0.20	3.45**	1.92	-0.46	-0.47	-0.04	4.35*	0.85
	(0.53)	(0.53)	(1.19)	(1.41)	(2.05)	(1.34)	(1.35)	(1.68)	(2.49)	(1.55)
Observations	1,154	1,154	1,153	1,142	878	1,154	1,154	1,153	1,142	878
R-squared	0.52	0.52	0.55	0.58	0.57					
Number of countryid	59	59	59	59	46	59	59	59	59	46
Number of Instruments						45	46	47	48	41
Hansen test						0.300	0.319	0.447	0.652	0.187
AR1 test p-value						0.0480	0.0476	0.0315	0.0105	0.00109
AR2 test p-value						0.115	0.119	0.129	0.194	0.184

*** p<0.01, ** p<0.05, * p<0.1. Industry clustered standard errors in parentheses. FE and GMM denote fixed effects and system GMM respectively. All regressions contain year fixed effects. GMM instrument set collapsed and limited to lags of 2 through 5 to reduce instrument count. FDI denotes foreign direct investment.

Table 3.4: Gross Fixed Capital Formation and Reserves, Controlling for Crises

	(1) FE	(2) FE	(3) GMM	(4) GMM
Lagged Private GFCF	0.59***	0.68***	0.78***	1.00***
	(0.10)	(0.04)	(0.15)	(0.09)
Reserves/GDP	-0.06	-0.09**	-0.09***	-0.10***
	(0.04)	(0.04)	(0.03)	(0.04)
Lagged RGDP Growth	0.08*	0.07	0.05	0.03
	(0.04)	(0.04)	(0.03)	(0.04)
Inflation	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Trade (% of GDP)	0.02*	0.02*	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.00)
Foreign Direct Investment (%GDP)	0.24***	0.18*	0.21***	0.06
	(0.07)	(0.09)	(0.08)	(0.04)
Banking Crisis		0.10		-0.12
		(0.99)		(0.85)
Currency Crisis		-0.48		-0.19
		(0.81)		(0.86)
Debt Crisis		-1.48***		-2.32***
		(0.50)		(0.67)
Constant	3.45**	2.54***	4.35*	0.84
	(1.41)	(0.91)	(2.49)	(1.48)
Observations	1,142	1,047	1,142	1,047
R-squared	0.58	0.61		
Number of countryid	59	57	59	57
Number of Instruments			48	51
Hansen test			0.652	0.488
AR1 test p-value			0.0105	0.000886
AR2 test p-value			0.194	0.0787

*** p<0.01, ** p<0.05, * p<0.1. Industry clustered standard errors in parentheses. FE and GMM denote fixed effects and system GMM respectively. All regressions contain year fixed effects. GMM instrument set collapsed and limited to lags of 2 through 5 to reduce instrument count.

Table 3.5: Gross Fixed Capital Formation and Lagged Reserves With Controls

	(1) FE	(2) FE	(3) FE	(4) FE	(5) FE	(6) GMM	(7) GMM	(8) GMM	(9) GMM	(10) GMM
Lagged Private GFCF	0.74***	0.74***	0.67***	0.60***	0.68***	0.98***	0.98***	0.94***	0.79***	0.97***
	(0.02)	(0.02)	(0.06)	(0.10)	(0.05)	(0.05)	(0.05)	(0.09)	(0.16)	(0.07)
L.Reserves/GDP	0.10***	0.10***	0.07*	0.07**	0.10**	0.11***	0.11***	0.09**	0.08**	0.14***
	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)
Lagged RGDP Growth	0.08	0.08*	0.09*	0.07*	0.04	0.05	0.05	0.05	0.04	0.00
	(0.05)	(0.04)	(0.04)	(0.04)	(0.06)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)
Inflation		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00
		(0.00)	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Trade (% of GDP)			0.05*	0.02	0.01			0.01	0.01	-0.00
			(0.03)	(0.01)	(0.01)			(0.02)	(0.01)	(0.01)
FDI (%GDP)				0.25***	0.16				0.21**	0.05
				(0.07)	(0.10)				(0.08)	(0.04)
Interest Payments (% GNI)					0.03					0.01
					(0.19)					(0.17)
Constant	4.46***	2.78***	0.22	3.49**	2.09	-0.55	-0.57	-0.14	2.72	-2.59
	(0.37)	(0.47)	(1.23)	(1.41)	(2.01)	(1.37)	(1.38)	(1.66)	(2.78)	(2.39)
Observations	1,154	1,154	1,153	1,142	878	1,154	1,154	1,153	1,142	878
R-squared	0.52	0.53	0.55	0.58	0.57					
Number of countryid	59	59	59	59	46	59	59	59	59	46
Number of Instruments						45	46	47	48	41
Hansen test						0.343	0.253	0.378	0.201	0.142
AR1 test p-value						0.0463	0.0459	0.0314	0.0101	0.000877
AR2 test p-value						0.123	0.126	0.134	0.200	0.208

*** p<0.01, ** p<0.05, * p<0.1. Industry clustered standard errors in parentheses. FE and GMM denote fixed effects and system GMM respectively. All regressions contain year fixed effects. GMM instrument set collapsed and limited to lags of 2 through 5 to reduce instrument count. FDI denotes foreign direct investment.

Table 3.6: Gross Fixed Capital Formation, Reserves and Lagged Reserves With Controls

	(1) FE	(2) FE	(3) FE	(4) FE	(5) FE
Lagged Private GFCF	0.74***	0.74***	0.67***	0.60***	0.68***
	(0.02)	(0.02)	(0.06)	(0.10)	(0.05)
Reserves (% of GDP)	-0.05	-0.05	-0.08**	-0.07**	-0.11**
	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)
Lagged Reserves (% of GDP)	0.11***	0.11***	0.08**	0.09**	0.12***
	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)
Lagged RGDP growth	0.07	0.08*	0.09*	0.07*	0.04
	(0.05)	(0.04)	(0.04)	(0.04)	(0.05)
Inflation		0.00	0.00	0.00	0.00
		(0.00)	(0.00)	(0.00)	(0.00)
Trade (% of)GDP			0.05*	0.02	0.01
			(0.03)	(0.01)	(0.01)
Foreign direct investment				0.24***	0.16*
				(0.07)	(0.10)
Interest payments (% GNI)					0.05
					(0.19)
Constant	4.53***	2.86***	0.20	3.44**	1.79
	(0.40)	(0.50)	(1.19)	(1.42)	(2.13)
Observations	1,154	1,154	1,153	1,142	878
R-squared	0.53	0.53	0.55	0.58	0.58
Number of Countries	59	59	59	59	46

*** p<0.01, ** p<0.05, * p<0.1. Industry clustered standard errors in parentheses. All regressions contain year fixed effects.

Table 3.7: List of Countries

Albania	Latvia
Algeria	Libya
Angola	Lithuania
Armenia	Macedonia, FYR
Azerbaijan	Malaysia
Barbados	Mauritius
Belarus	Mexico
Bolivia	Moldova
Bosnia and Herzegovina	Mongolia
Botswana	Namibia
Brazil	Nicaragua
Bulgaria	Oman
Colombia	Pakistan
Congo, Republic of	Panama
Costa Rica	Peru
Croatia	Philippines
Dominican Republic	Russia
Egypt	South Africa
El Salvador	Sri Lanka
Equatorial Guinea	Swaziland
Gabon	Syrian Arab Republic
Georgia	Trinidad and Tobago
Guatemala	Thailand
Honduras	Tunisia
India	Turkey
Iran, I.R. of	Ukraine
Jamaica	United States
Japan	Uruguay
Jordan	Venezuela
Kazakhstan	

Table 3.8: Real Effective Exchange Rates and Reserve Accumulation

	(1) FE	(2) FE	(3) FE
Lagged REER	0.11***	0.11***	0.11***
	(0.00)	(0.00)	(0.00)
2nd Lag, REER			0.03***
			(0.00)
Reserves (% of GDP)	-6.61	-5.88	-6.77
	(6.80)	(6.03)	(6.68)
Lagged Reserves (% of GDP)		-3.75	-2.68
		(4.08)	(2.99)
2nd Lag, Reserves (% of GDP)			-7.63
			(7.87)
Constant	178.00***	183.74***	193.78***
	(13.13)	(19.40)	(32.14)
Observations	1,010	1,010	951
R-squared	0.01	0.01	0.01
Number of Countries	55	55	55

*** p<0.01, ** p<0.05, * p<0.1. Clustered standard errors in parentheses
Fixed effects estimates presented as system GMM suffers from weak instruments.

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Appendix A

Ancillary materials

Table A.1: Gross Fixed Capital Formation and Lagged Reserves With Lagged Controls

	(1) FE	(2) FE	(3) FE	(4) FE	(5) FE	(6) GMM	(7) GMM	(8) GMM	(9) GMM	(10) GMM
Lagged Private GFCF	0.74***	0.74***	0.73***	0.70***	0.73***	0.98***	0.98***	0.97***	0.91***	0.99***
	(0.02)	(0.02)	(0.02)	(0.04)	(0.03)	(0.05)	(0.05)	(0.06)	(0.11)	(0.10)
Lagged Reserves/GDP	0.10***	0.10***	0.10***	0.09**	0.12***	0.11***	0.11***	0.10***	0.09**	0.14***
	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
Lagged RGDP Growth	0.08	0.08*	0.08*	0.07	0.04	0.05	0.05	0.05	0.05	0.01
	(0.05)	(0.05)	(0.05)	(0.05)	(0.07)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)
L.Inflation		0.00	0.00	0.00	0.00		-0.00	-0.00	-0.00	-0.00
		(0.00)	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
L.Trade (% of GDP)			0.00	-0.01	-0.01			0.00	0.00	-0.01
			(0.02)	(0.01)	(0.02)			(0.01)	(0.01)	(0.01)
L.FDI (%GDP)				0.13	-0.00				0.11	-0.06
				(0.10)	(0.06)				(0.13)	(0.08)
L.Interest Payments (% GNI)					-0.13					-0.11
					(0.10)					(0.18)
Constant	4.46***	4.45***	4.31***	3.62***	4.78***	-0.55	-0.53	-0.33	0.84	-1.99
	(0.37)	(0.37)	(1.03)	(0.96)	(1.36)	(1.37)	(1.37)	(1.38)	(2.23)	(2.47)
Observations	1,154	1,153	1,152	1,139	857	1,154	1,153	1,152	1,139	857
R-squared	0.52	0.52	0.52	0.53	0.56					
Number of countryid	59	59	59	59	46	59	59	59	59	46
Number of Instruments						45	46	47	48	40
Hansen test						0.238	0.237	0.210	0.306	0.121
AR1 test p-value						0.0463	0.0471	0.0388	0.0147	0.00108
AR2 test p-value						0.123	0.121	0.130	0.197	0.384

*** p<0.01, ** p<0.05, * p<0.1. Industry clustered standard errors in parentheses. FE and GMM denote fixed effects and system GMM respectively. All regressions contain year fixed effects. GMM instrument set collapsed and limited to lags of 2 through 5 to reduce instrument count. FDI denotes foreign direct investment.

Table A.2: Data Sources

Private Gross Fixed Capital Formation (% of GDP)	IMF Financial Statistics
Reserves (% of GDP)	IMFs Balance of Payments Statistics Yearbooks
RGDP Growth	World Development Indicators
Inflation (GDP Deflator, %)	World Development Indicators
Trade (% of GDP)	World Development Indicators
Foreign Direct Investment (% of GDP)	IMFs Balance of Payments Statistics Yearbooks
Interest Payments on External Debt (% of GNI)	World Development Indicators
Banking Crisis Indicator	[Laeven and Valencia, 2008]
Currency Crisis Indicator	[Laeven and Valencia, 2008]
External; Debt Crisis Indicator	[Reinhart and Rogoff, 2010]
Real Effective Exchange Rate	[Darvas, 2012]