Essays on Economic Policy and Consumer Sentiment

by

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A dissertation submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Doctor of Philosophy

Auburn, Alabama
August 3, 2019

Keywords: Fiscal Policy, Policy Coordination, Consumer Sentiment, Survey of Professional Forecaster, Greenbook

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Abstract

To boost aggregate demand and create new jobs for the U.S. economy, the U.S. government enacted the American Recovery and Reinvestment Act (ARRA) during the recent Great Recession, one of the largest fiscal stimulus programs in American history. The sluggish economic recovery from the Great Recession has triggered heated debates over the effectiveness of fiscal policy in stimulating the economy. Some researchers report positive economic effects of fiscal stimulus following New Keynesian approach whereas others argue that fiscal stimulus does not appear to stimulate the economy employing neoclassical models. Besides, another group of scholars proposes nonlinear effects of fiscal stimulus depending on the current state of the economy. Given the divided literature on this issue, the objective of this research is to evaluate the effectiveness of fiscal policy in the U.S. under different monetary and fiscal policy regimes. Using a New Keynesian DSGE model with two distinct policy regimes and structural VAR estimation, the first part of our research shows that fiscal policy has become ineffective due to lack of coordination between monetary and fiscal policy. To account for the changes in the fiscal policy transmission, we propose sentiment as an alternative propagation mechanism. We further provide evidence of the sentiment channel through the lens of the Survey of Professional Forecasters data. The second part of our research is the sequel to the first part, which focuses on whether fiscal policy can improve the labor market conditions by identifying shocks to government employment. In this part, we develop a two-sector NK DSGE model and assess the validity of simulation results via a recursively identified VAR model. Also, we highlight dynamic adjustments of sentiment to explain the changing labor market responses to fiscal shocks employing the SPF data. Consistent with the first part, our results show that fiscal stimulus fails to improve labor market conditions if there is consumer pessimism when fiscal and monetary policies are conflicted with each other. In the third part, we examine how forecasters revise their economic prospects through recovering the forecast errors of real GDP growth, unemployment growth and inflation applying the law of iterated projection from the

Survey of Professional Forecasters (SPF) and the Greenbook. We point out the existence of systematic bias in both the private sector and Federal Reserve forecasters' expectations. Motivated by the first two parts, we conjecture that the persistent forecast bias with changed sign might be closely related to changing fiscal and monetary policy regimes.

Acknowledgments

Undertaking this Ph.D has been a truly life-changing experience for me. Since my first day of Auburn on August 8th, 2013 I have felt at home. This dissertation represents not only my work at Auburn, it is the result of many experiences I have encountered from dozens of remarkable individuals who I wish to acknowledge.

First and foremost, I'm deeply indebted to my advisor **Prof. Hyeongwoo Kim** for his patience, motivation, and immense knowledge. You have been a tremendous mentor for me. You have taught me, both consciously and unconsciously, how good research is done. When you got interesting topics, related literature or any useful resource, you always share with me. The joy and enthusiasm you have for your research was contagious and motivational for me. When my research came to halt, you inspired me to broaden my mind and contributed valuable advice and encouragement. I remember you always told me "You can make it!". Under your supervision, I learned how to define a research problem, find a solution to it and finally publish the results. What's more, during tough time in the job market, you were always accessible and kept telling me " You will get a job!". You provided me with every bit of enlightenment, assistance, and expertise that I needed during my Ph.D study, which make my Ph.D experience productive and stimulating. Without your guidance and constant feedback this Ph.D would not have been achievable.

I would like to sincerely thank the members of my dissertation committee for their great support and invaluable advice. I owe a debt of gratitude to **Prof. Nicolas L. Ziebarth** for his time and crucial remarks that shaped my final dissertation. To **Prof. Gilad Sorek**, I thank him for teaching me important macroeconomic knowledge and his untiring support throughout my Ph.D study. To **Prof. Thomas R. Beard**, thank you for modeling outstanding educator and insightful suggestions for my research and job interviews. To **Prof. Michael L. Stern**, thank you for the enormous amount of care, help and encouragement during my graduate school career. To **Prof. Duha T. Altindag**, thank you for being part of my dissertation committee and helpful career advice. I also show sincere thanks to my dissertation reader **Prof. Myoung Gi Chon**.

Especially helpful for me during the Ph.D. study is **Prof. Alexander W. Richter** (Senior Economist and Advisor at the Federal Reserve Bank of Dallas), who has mentored me for three years. When he was in Auburn, his series of course in the field of macroeconomics have had substantial influence on my research. He also provided me with a fantastic modelling and coding training. With his help, I received an internship at Dallas Fed which played a crucial role in my academic career. I must also thank **Prof. Nathaniel A. Throckmorton** (Assistant Professor of Economics at William & Mary) for his continuous support in both my research and job search.

I would like to extend my sincere thanks to all others who have helped and taught me immensely in the Department of Economics at Auburn University. A special thank you to **Prof. Aditi Sengupta** for the excellent example she has provided as a successful woman economist and professor. I would particularly like to thank **Prof. Liliana V. Stern**. I greatly value the close rapport that Lily and I have forged over the years. I'm so grateful to **Prof. Chris Vickers** for his guidance and assistance to equip me with improved skills and knowledge in the job market. I'll also not forget the help I received from **Prof. Henry Thompson**, **Prof. Alan Seals**, **Dr. Sara Seals**, **Dr. Macy Finck**, **Mr. John Sophocleus** and **Ms. Jennifer Bruno** during my graduate career and I will always be grateful to them.

I'm also thankful to other past and present graduate students that I have had the pleasure to work with. I'm quite appreciative of **Dr. Wen shi** and **Dr. Ghislain N. Gueye** for offering me advice and support through the job-looking process. My special thanks go to **Dr. Eric Wilbrandt**, **Dr. Bharat Diwakar**, **Ms. Jiayi Xu**, **Mr. Qian Liang** and **Mr. Greg Gilbert** for the sleepless nights we were working together before deadlines. I'm so grateful to **Ms. Jie Zhang**, **Ms. Yunxiao Zhang**, **Mr. Sarthak Behera**, **Ms. Divya Sandana** and **Mr. Haiyue Zhao** for all the great time that we have shared.

I also gratefully acknowledge my colleagues from my internship at the Federal Reserve Bank of Dallas. I spent 5 months at the bank where I had the chance to collaborate with fantastic economists. More specifically, I would like to thank **Dr. Mine Kuban Yücel**, **Dr. Michael**

D. Plante and **Dr. Nida Cakir Melek** (Federal Reserve Bank of Kansas) for providing me the great opportunity to work on energy policy projects. I particularly want to thank **Dr. Wenhua Di** and **Dr. Ruiyang Hu** for making my experience in the bank impressive and exciting. I would like to thank **Dr. Christoffer Koch** and **Dr. Anton A. Cheremukhin** for their helpful comments in my research.

I also thank an organization: Auburn Global Program. I feel so blessed to be a faculty member of Auburn Global where I was given the opportunity to teach heterogeneous grouping of students. I want to especially thank **Prof. Robert Weigel** for great support in my teaching and writing me a letter of recommendation.

My time at Auburn was made enjoyable in large part due to many friends that became a part of my life. I very much appreciate **Mr. Ted Gibson**, **Ms. Sherry Gibson** and their sons and daughter-in-laws: **Dr. Matt Gibson**, **Dr. Sarah H. Gibson**, **Mr. Chris Gibson** and **Ms. Stacie G. Gibson**. Thanks for making my life in the U.S unique, special and so much fun. I'm also so grateful for time spent with **Dr. Xinyu Zhao**, **Dr. Song Gao**, **Dr. Rui Chen**, **Dr. Hao Wu**, **Dr. Liang Tang**, **Mr. Xiaoning Li**, **Ms. Yawei Chen**, **Mr. Yusheng Ding**, **Mr. Kang Sun**, **Ms. Ya-Chi Kuo**, **Ms. Junweiran Wang**, **Mr. Yecheng Xu** and many other people who provided happy distraction to rest my mind outside of my research. To my friends in China, thank you for your well-wishes and being there whenever I needed a friend.

I would like to express my deepest gratitude to my family in China. I have an amazing family, unique in many ways. This dissertation would not have been possible without their warm love, sacrifice, and endless support in all my pursuits. I dedicate this dissertation to them. The last word of acknowledgment I have saved for my best friend, soul-mate and husband **Jue Wang**. These past several years have not been an easy ride but I feel safe, comfortable and happy just because I know that the perfect man to live my life with is always there for me.

I dedicate this dissertation to the loving memory of my grandfather Yishou Zhang and grandmother Caiyun Xu.

Shuwei Zhang
Auburn University
April 2019

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Chapter 1

Understanding Why Fiscal Stimulus Can Fail through the Lens of the Survey of Professional Forecasters *with Hyeongwoo Kim*

1.1 Introduction

The sluggish economic recovery from the recent Great Recession has triggered heated debates on the effectiveness of fiscal policy in stimulating private activity. One group of researchers reports significantly positive output effects of fiscal stimulus, which can be consistent with the New Keynesian macroeconomic model. However, such effects could be replicated only in heavily restricted models. See, among others, Rotemberg and Woodford (1992), Devereux et al. (1996), Fatás and Mihov (2001), Blanchard and Perotti (2002), Perotti (2011), and Galí et al. (2007).

Many others, on the other hand, are skeptical about the effectiveness of fiscal policy. For instance, Ramey (2011b) points out that expansionary government spending shocks tend to decrease consumption due to a negative wealth effect. See, among others, Aiyagari et al. (1992), Hall (1986), Ramey and Shapiro (1998), Edelberg et al. (1999), Burnside et al. (2004), Cavallo (2005), Mountford and Uhlig (2009), Ramey (2012), and Owyang et al. (2013).

Another interesting question is whether fiscal policy has nonlinear effects on output depending on the current state of the economy. For example, Fazzari et al. (2015), Auerbach and Gorodnichenko (2012), Mittnik and Semmler (2012), and Bachmann and Sims (2012) claim that fiscal policy tends to have a stronger output effect during times of slack, whereas Kim and Jia (2017), Owyang et al. (2013), and Ramey and Zubairy (2018) find no such evidence. On the other hand, Hall (2009) and Christiano et al. (2011) suggest that the government spending multiplier can be greater when the nominal interest rate is bounded at zero. Corsetti et al. (2012) and Ilzetzki et al. (2013) report some international evidence that the effectiveness of government stimulus depends on country characteristics such as the exchange rate regime and public indebtedness.

In their recent work, Leeper et al. (2017) proposed an interesting theoretical framework that generates substantially weaker responses of private spending to expansionary fiscal policy shocks in an active monetary/passive fiscal policy regime (Regime M) than in a passive monetary/active fiscal policy regime (Regime F).[1]

Motivated by their work, we evaluate the effectiveness of fiscal policy under different monetary and fiscal policy regimes. Finding no compelling empirical evidence of passive fiscal policy, however, we focus on the monetary policy stance that tends to change over time given the active stance of fiscal policy.[2] We assume that the central bank maintains a dovish policy stance that coordinates well with expansionary fiscal policy in regime D. In regime H, however, monetary policy makers respond aggressively to inflationary pressure, conflicting with fiscal stimulus. That is, we assume that fiscal and monetary policy are well coordinated only in regime D. Our simulation results demonstrate that private spending positively responds to the government spending shock in regime D, whereas it responds negatively in regime H, resulting in substantially weaker stimulating effects on the total output. In what follows, our theoretical model shows that the real interest rate plays a key role in generating qualitatively different output effects across the two regimes.

Employing the post-war U.S. macroeconomic data, we investigate the empirical validity of these predictions of our model. We report strong evidence of the time-varying effectiveness of fiscal policy with a possibility of structural breaks in the propagation mechanism of the government spending shock across time. Specifically, we observed strong stimulating effects of government spending on private economic activity in earlier sample periods when the Fed stayed accommodative, while government spending shocks tend to discourage economic activity in the private sector when the Fed shifted to a hawkish stance, conflicting with expansionary fiscal policy.

[1]An active monetary policy regime refers a case that the monetary authority responds to inflation aggressively. A passive fiscal policy regime means that dynamics of government spending has a strong feedback from rising government debt.

[2]We observe the federal government deficit in 75 out of 89 years from 1929 to 2017, which is about 84% odds (FYFSGDA188S; FRED).

Although these findings are overall consistent with the predictions of our proposed model, we noticed a negligibly weak role of the real interest rate in propagating fiscal stimulus to economic activity, which is inconsistent with our benchmark New Keynesian model. To resolve this issue, we propose an alternative explanation for the observed time-varying output effects of fiscal policy shocks using a sentiment channel. We are not the first to introduce the role of sentiment as one of potential drivers of macroeconomic fluctuations. See, among others, Hall (1993), Blanchard (1993), Cochrane (1994), Beaudry and Portier (2006, 2007), Bachmann and Sims (2012) and Kim and Jia (2017).

For this purpose, we investigate how market participants revise their economic prospects when they receive new information on the stance of fiscal policy through the lens of the Survey of Professional Forecasters (SPF) data. We show that forecasters tend to over-predict GDP growth when monetary policy coordinates well with fiscal policy, while systemic under-predictions are likely to occur when the Fed adopts a hawkish stance. We view persistent over-predictions as a sign of optimism, while under-predictions reflect pessimistic economic prospects in the market.

We further investigate this conjecture by regressing five-quarter ahead forecasts of real GDP growth on one-quarter ahead forecasts of real government spending growth employing a fixed-size rolling window scheme. Results reveal strong positive correlations (optimism) for the pre-Volcker era, while we observed negative correlations (pessimism) when the stance of monetary policy became hawkish. These findings imply that time-varying responses in sentiment may explain the time-varying effectiveness of fiscal policy on private spending. In regime D, fiscal stimulus generates consumer optimism, which stimulates economic activity in the private sector. In regime H, however, it generates consumer pessimism, resulting in subsequent decreases in private spending, which ultimately weaken the effectiveness of fiscal policy. We also provide statistical evidence in favor of such views employing structural break tests by Hansen (1997, 2001).

Leeper et al. (2017) also demonstrate that fiscal policy can be less effective when the monetary authority stays hawkish. However, their contributions are mostly theoretical because their major findings are based on counterfactual analyses using the full sample period data. On the contrary, we provide historical evidence of the time-varying effects of fiscal stimulus for the post-war U.S. data. Furthermore, we suggest a sentiment channel as an alternative to the real interest rate channel to explain the output effects of fiscal policy under different policy regimes.

Perotti (2005) suggests similar evidence that fiscal policy became less effective in more recent sample periods using macroeconomic data from 5 OECD countries including the U.S. However, he fails to provide convincing explanations what caused such changes. Bilbiie et al. (2008) also report time-varying effects of fiscal stimulus, but they focus more on the role of different feedback rules of government spending as in Leeper et al. (2017). They suggest that financial market deregulation made it possible for households to smooth consumption, which makes fiscal policy less effective.[3] It seems, however, that these arguments are at odds with the data. In effect, saving rates have substantially declined since the 1980's when deregulation began in the U.S.

The remainder of this paper is organized as follows. Section 2 presents our baseline New Keynesian models. Section 3 reports simulation results that highlight qualitatively different output effects of fiscal stimulus across regimes. In Section 4, we present our empirical models along with data descriptions. We demonstrate time-varying responses of our key economic variables to government spending shocks. We provide strong evidence of a weak role of the real interest rate in propagating fiscal stimulus over time. We then discuss a possibility of the existence of a sentiment channel as an alternative. Employing the SPF data, section 5 provides a novel statistical approach that extracts useful information on how market participants revise their economic prospects when they receive new information on government spending. We show market agents become more optimistic in regime D in response to the government spending shock, while they become pessimistic in regime H, which helps explain weaker output effects of fiscal policy in regime H. Section 6 concludes.

[3]They argue that more savings instruments became available due to financial market deregulation, which helped households to act in line with the permanent income hypothesis.

1.2 The Theoretical Model

We present a standard New Keynesian model that features external habit formation in consumption, variable capacity utilization, investment adjustment costs, and monopolistic competition in the production. Sticky prices and sticky wages are modeled using the framework of Calvo (1983) and Yun (1996). Government spending directly enters household's utility as a complement to private consumption, because this specification in a sticky-price model turns out to help reconcile theory and empirical evidence. For more details, see among others, Linnemann and Schabert (2004) and Leeper et al. (2017). Monetary authority follows a Taylor rule, while fiscal rules are specified with a feedback to government debt as described in Leeper et al. (2017). In what follows, we demonstrate the effectiveness of fiscal stimulus critically hinges upon the stance of monetary policy.

1.2.1 Firms and Price Setting

The final good (y_t) is a composite good of a continuum of intermediate goods (y_{it}), characterized by a Dixit and Stiglitz (1977) aggregator, $y_t = \left[\int_0^1 y_{it}^{(\theta_p-1)/\theta_p} di\right]^{\theta_p/(\theta_p-1)}$, where $\theta_p > 1$ governs the degree of substitution between the inputs. Taken input prices (P_{it}) and the output price $P_t = \left(\int_0^1 P_{it}^{1-\theta_p} di\right)^{1/1-\theta_p}$ as given, the profit maximization yields the demand for intermediate good i, $y_{it} = (P_{it}/P_t)^{-\theta_p} y_t$. The intermediate good i is produced by a monopolistically competitive firm who has the following production function:

$$y_{it} = (k_{it}^s)^\alpha n_{it}^{1-\alpha}, \tag{1.1}$$

where $\alpha \in (0,1)$. n_{it} and k_{it}^s denote the level of labor hours and capital services used by firm i, respectively.[4]

Each monopolistically competitive firm solves a two-stage problem. In the first stage, taken input prices (w_t and r_t^k), as given, each firm rents labor (n_{it}) and capital (k_{it}^s) to minimize its operating cost, $w_t n_{it} + r_t^k k_{it}^s$, subject to its production function (1.1). Cost minimization

[4] k_{it}^s is the effective amount of capital, which is introduced in the next section.

yields the identical real marginal cost:

$$mc_t = \sigma w_t^{1-\alpha} \left(r_t^k \right)^{\alpha}, \tag{1.2}$$

where $\sigma = \left(\frac{1}{1-\alpha}\right)^{1-\alpha} \left(\frac{1}{\alpha}\right)^{\alpha}$. In the second stage, each intermediate goods firm chooses its price (P_{it}) to maximize the discounted present value of future profits subject to the demand for y_{it}.

Following the price-setting scheme proposed by Calvo (1983), intermediate firm i can reset its price (P_{it}^*) with a fixed probability $(1-\omega_p)$. With probability ω_p, it partially indexes its price to past inflation according to the following rule:

$$P_{it} = \pi_{t-1}^{\iota_p} \bar{\pi}^{1-\iota_p} P_{it-1}, \tag{1.3}$$

where $\pi_t \equiv \frac{P_t}{P_{t-1}}$ is the gross inflation rate between $t-1$ and t, while $\bar{\pi}$ is the steady state inflation. Note that indexation is controlled by the parameter $\iota_p \in [0,1]$ that allows any combinations of the two types of indexation usually employed in the literature, steady state inflation (e.g., Yun (1996)) and the past inflation rate (e.g., Christiano et al. (2005)). Throughout this paper, variables with a bar denote steady state values.

The profit maximization problem for firm i that reoptimizes its price at time t is:

$$\begin{aligned} \max_{P_{it}^*} \; & E_t \sum_{s=0}^{\infty} (\omega_p \beta)^s \frac{\lambda_{t+s}}{\lambda_t} \left[\left(\frac{\Xi_{t,s}^p P_{it}^*}{P_{t+s}} - mc_{t+s} \right) y_{it+s} \right] \\ & s.t. \quad y_{it+s} = \left(\frac{\Xi_{t,s}^p P_{it}^*}{P_{t+s}} \right)^{-\theta_p} y_{t+s} \\ & \Xi_{t,s}^p = \left\{ \begin{array}{c} 1 \quad \text{for} \quad s=0 \\ \prod_{k=1}^{s} \pi_{t+k-1}^{\iota_p} \bar{\pi}^{1-\iota_p} \quad \text{for} \quad s \geq 1 \end{array} \right\}, \end{aligned} \tag{1.4}$$

where the profit at time $t+s$ is discounted by the pricing kernel $\beta^s \left(\lambda_{t+s}/\lambda_t\right)$ and λ_t is the marginal utility (or shadow price) of wealth of households at time t that appears in the following subsection. The optimality condition from (1.4) implies:

$$E_t \sum_{s=0}^{\infty} (\omega_p \beta)^s \frac{\lambda_{t+s}}{\lambda_t} \left[\frac{\Xi_{t,s} P_{it}^*}{P_{t+s}} - \mathcal{M}^p mc_{t+s} \right] y_{it+s} = 0 \tag{1.5}$$

where $\mathcal{M}^p \equiv \frac{\theta_p}{\theta_p - 1}$. The aggregate price index evolves as follows:

$$1 = (1 - \omega_p) (\pi_t^*)^{1-\theta_p} + \omega_p \left(\frac{\pi_{t-1}^{\iota_p} \pi^{1-\iota_p}}{\pi_t} \right)^{1-\theta_p} \tag{1.6}$$

where $\pi_t^* = \frac{P_t^*}{P_t}$.

1.2.2 Households and Wage Setting

There is a continuum of households on the unit interval $[0,\ 1]$ indexed by j. In addition to hours worked (n_{jt}), each household j derives utility from composite consumption (c_{jt}^*) which consists of private goods (c_{jt}) and public goods (g_t), that is, $c_{jt}^* \equiv c_{jt} + \alpha_g g_t$. Parameter α_g governs the degree of substitutability/complementarity of the consumption goods. When $\alpha_g < 0$, private and public consumption are complements (Leeper et al. (2017)), whereas $\alpha_g > 0$ implies that these are substitutes with each other (Christiano and Eichenbaum (1992); Ambler and Paquet (1996); Finn (1998)). Household j maximizes the following lifetime utility,

$$E_t \sum_{t=0}^{\infty} \beta^t \left[\ln \left(c_{jt}^* - h c_{t-1}^* \right) - \chi \frac{n_{jt}^{1+\eta}}{1+\eta} \right], \tag{1.7}$$

where $\beta \in (0,1)$ is the discount factor and $h \in (0,1)$ denotes the external habit formation parameter. To put it differently, we define the habit stock by a fraction of lagged aggregate consumption ($h c_{t-1}^*$). χ is the disutility parameter from work and $1/\eta$ determines the Frisch elasticity of labor supply.

The household's real flow budget constraint is given by:

$$c_{jt} + i_{jt} + \frac{B_{jt}}{P_t} \leq \frac{R_{t-1} B_{jt-1}}{P_t} + (1 - \tau^n) w_{jt} n_{jt} + \left[\left(1 - \tau^k\right) r_t^k u_{jt} - a(u_{jt}) \right] k_{jt-1} + d_{jt} + tr \tag{1.8}$$

where the left-hand side represents the uses of income, private consumption (c_{jt}), investment (i_{jt}), and purchases of nominal government debt (B_{jt}) deflated by P_t. The right-hand side denotes the sources of income consisting of real interest payments of government debt, after-tax real wage (w_{jt}) and capital rental (r_t^k) income, dividends distributed by the intermediate goods firms (d_{jt}), and constant lump-sum transfer payments (tr) from the government. τ^n and τ^k are constant tax rates levied on labor income and capital, respectively.[5]

The effective amount of capital services is represented by $k^s_{jt} \equiv u_{jt}k_{jt-1}$, whereas $a(u_{jt})k_{jt-1}$ describes the physical cost associated with variations in the degree of capacity utilization, which is parameterized by a quadratic function, $a(u_{jt}) = \zeta_1 (u_{jt} - 1) + \frac{\zeta_2}{2} (u_{jt} - 1)^2$. [6] Note that $u = 1$ and $a(1) = 0$ in the steady state. We also define $\frac{a''(1)}{a'(1)} \equiv \frac{\zeta_2}{1-\zeta_2}$ following Smets and Wouters (2007).[7]

The law of motion for capital is:

$$k_{jt} = (1-\delta) k_{jt-1} + \left[1 - S\left(\frac{i_{jt}}{i_{jt-1}}\right)\right] i_{jt}, \tag{1.9}$$

where δ is the depreciation rate and $S(\cdot)$ denotes an adjustment cost function, proposed by Christiano et al. (2005), such that $S(1) = S'(1) = 0$, and $\kappa \equiv S''(1) > 0$.

There is a representative, competitive labor agency that hires a continuum of differentiated labor from each household with the following aggregator:

$$n_t = \left[\int_0^1 n_{jt}^{\frac{\theta_w - 1}{\theta_w}} dj\right]^{\frac{\theta_w}{\theta_w - 1}}, \tag{1.10}$$

where $0 \leq \theta_w < \infty$ is the elasticity of substitution among different types of labor. This competitive labor agency maximizes its profit subject to this production function, taking all differentiated labor wages (w_{jt}) and the aggregate wage (w_t) as given, yielding:

$$n_{jt} = \left(\frac{w_{jt}}{w_t}\right)^{-\theta_w} n_t, \tag{1.11}$$

where w_t is the aggregate real wage that satisfies $w_t = \left(\int_0^1 w_{jt}^{1-\theta_w} dj\right)^{\frac{1}{1-\theta_w}}$.

Following Erceg et al. (2000), wage stickiness is introduced in a way that is analogous to price stickiness described above. In each period, a fraction $1-\omega_w$ of households can adjust their

[5] We assume constant tax rates to focus mainly on the transmission channel of government spending given the tax policy.

[6] Note that we use the *end of period stock* timing convention. For example, k_{t-1} is the capital stock that was determined by investment at time $t-1$, but is used at time t in the production function for y_t.

[7] We need this condition to linearize the model presented here.

wages to w_{jt}^* and others can only index their wages by past inflation as $w_{jt} = \pi_{t-1}^{\iota_w} \bar{\pi}^{1-\iota_w} w_{jt-1}$, where indexation is controlled by the parameter $\iota_w \in [0,1]$. Therefore, the wage-setting problem of households who reset their wages at time t can be written as:

$$\max_{w_{jt}^*} \ E_t \sum_{s=0}^{\infty} (\omega_w \beta)^s \, U\left(c_{jt+s}, n_{jt+s}\right) \tag{1.12}$$
$$s.t. \quad n_{jt+s} = \left(\frac{\Xi_{t,s}^w w_{jt}^*}{w_{t+s}}\right)^{-\theta_w} n_{t+s}$$
$$\Xi_{t,s}^w = \left\{ \begin{array}{cc} 1 \quad \text{for} \quad s=0 \\ \prod_{k=1}^s \pi_{t+k-1}^{\iota_w} \bar{\pi}^{1-\iota_w} \quad \text{for} \quad s \geq 1 \end{array} \right\}$$

The first order condition associated with this wage-setting problem can be written as:

$$\sum_{s=0}^{\infty} (\omega_w \beta)^s \, E_t \left[\frac{n_{jt+s}}{\tilde{c}_{t+s}} \left(\frac{\Xi_{t,s}^w w_{jt}^*}{P_{t+s}} - \mathcal{M}^w MRS_{jt+s} \right) \right] = 0 \tag{1.13}$$

where $\mathcal{M}^w \equiv \frac{\theta_w}{\theta_w - 1}$, $\tilde{c}_{t+s} \equiv c_{t+s}^* - h c_{t+s-1}^*$, and $MRS_{jt+s} \equiv \varrho \tilde{c}_{t+s} n_{jt+s}^{\eta}$ is the relevant marginal rate of substitution between consumption and labor hours in period $t+s$. Therefore, the aggregate wage index is described as follows:

$$1 = (1-\omega_w) \left(\pi_{w,t}^*\right)^{1-\theta_w} + \omega_w \left(\frac{\pi_{t-1}^{\iota_w} \pi^{1-\iota_w}}{\pi_t} \frac{w_{t-1}}{w_t} \right)^{1-\theta_w} \tag{1.14}$$

where $\pi_{w,t}^* = \frac{w_t^*}{w_t}$.

1.2.3 Monetary and Fiscal Authorities

The monetary policy follows a Taylor rule. It adjusts the gross nominal interest rate (R_t) in response to deviations of inflation (π_t) and output (y_t) from their respective steady state levels:

$$R_t = R_{t-1}^{\psi_r} \left[\bar{R} \left(\frac{\pi_t}{\bar{\pi}} \right)^{\phi_\pi} \left(\frac{y_t}{\bar{y}} \right)^{\phi_y} \right]^{1-\psi_r} \tag{1.15}$$

where $0 \leq \psi_r < 1$ is the interest rate smoothing parameter, $\bar{R}$ is the equilibrium real interest rate, ϕ_π and ϕ_y are the policy response parameters to the inflation gap and the output gap, respectively.

The government collects tax revenues from capital and labor in addition to its sales of one-period debt to finance its expenditures that include interest payments, government expenditures (g_t) and transfer payments (tr). The government's flow budget constraint is:

$$\frac{B_t}{P_t} + \tau^n w_t n_t + \tau^k r_t^k u_t k_{t-1} = \frac{R_{t-1} B_{t-1}}{P_t} + g_t + tr \tag{1.16}$$

Government expenditures (g_t) obey the following stochastic process:

$$g_t = g_{t-1}^{\psi_g} \left[\bar{g} \left(b_{t-1}/\bar{b} \right)^{-\gamma_g} \right]^{1-\psi_g} \nu_{g,t} \tag{1.17}$$

where the parameter $\psi_g \in (-1, 1)$ governs the degree of the persistence of g_t. Following Leeper et al. (2017), we allow government spending to respond to deviations of the (lagged) real debt $b_{t-1} = \frac{B_{t-1}}{P_{t-1}}$ from its stead state value $\bar{b}$. That is, the parameter $\gamma_g > 0$ triggers a correction of government spending when real debt deviates from its steady state value. $\nu_{g,t}$ is a government spending shock, which is assumed to follow a stationary ($\rho_g < 1$) AR(1) process:

$$\ln \nu_{g,t} = \rho_g \ln \nu_{g,t-1} + \sigma_g \varepsilon_{g,t}, \varepsilon_{g,t} \sim \mathbb{N}(0, 1) \tag{1.18}$$

1.2.4 Market Clearing and Aggregation

We consider a symmetric equilibrium in which all intermediate good firms make identical choices so that the subscript i can be omitted. All goods and asset markets clear in the equilibrium. Specifically, the goods market clear condition requires the following aggregate resource constraint:

$$y_t = c_t + i_t + g_t + a(u_t) k_{t-1}, \tag{1.19}$$

where capital evolves according to the law of motion for capital (1.9). Equilibrium conditions and their log-linearized equivalents around the deterministic steady state are given in the Appendix. The log-linearized model is solved using the Sims (2002) gensys algorithm.

1.3 Model Simulations

1.3.1 Calibration

The model is calibrated at a quarterly frequency. Regime specific monetary policy parameters are based on the estimates reported by Clarida et al. (2000) to investigate the effects of structural breaks in the Fed's behavioral equation. Other model parameters are along the lines of research works in the literature or were calibrated using U.S. data over the period $1960Q1 - 2017Q3$. Benchmark calibration parameter values are summarized in Table 1.1.

The discount factor (β) is set to 0.9958, which equals $(1/T)\sum_{t=1}^{T}\pi_t/(1+(FFR_t/100))^{1/4}$ where T is the sample size from the data, π_t denotes the quarterly gross inflation rate, and FFR_t is the effective federal funds rate. The inverse Frisch labor supply elasticity ($1/\eta$) is fixed at 2, which is a common value in the current literature. We set $\delta = 0.025$ for the quarterly depreciation rate for capital that implies an annual depreciation rate of 10%. The disutility parameter (χ) is an implied parameter that is calibrated with other parameters so that hours worked in the steady state is close to $1/3$ in a model with divisible labor.[8] The habit formation coefficient (h) and the complementarity parameter (α_g) of consumption between private goods and public goods are set to 0.99 and -0.2, respectively, which are similar to the ones in Leeper et al. (2017).

The Cobb-Douglas factor share of capital (α) is set to 0.33. The price elasticity of demand for individual good (θ_p) and the elasticity of substitution among different types of labor (θ_w) are all calibrated to be 8. The capital utilization rate (ζ_2) and the adjustment cost for investment (κ) are set to 0.15 and 5, respectively, being consistent with the estimation results in Leeper et al. (2017). The parameters for price stickiness (ω_p) and wage stickiness (ω_w) are both assumed to be 0.8, implying a slightly over one-year average duration of price/labor contracts.

[8]This roughly matches the observation that individuals spend $1/3$ of their time engaged in market activities and $2/3$ of their time in non-market activities. See Hansen (1985).

Monetary and fiscal parameters are calibrated based on the mean values from U.S. data over the same sample period in the present paper. The steady state gross quarterly inflation rate ($\bar{\pi}$) is assumed to be 1.0082. The total government spending-to-GDP ratio (s_g) is set to 0.0945. The government debt-to-GDP ratio (s_b) is 1.3707. The persistence parameter (ρ_g) of government spending is assumed to be 0.98. The average labor tax rate (τ^n) is set to 0.2171 and the capital tax rate (τ^k) is 0.2497.

To highlight the implications of policy coordination of monetary and fiscal policies, we define the following two regimes. In regime D, policy makers stay accommodative in the stance of both monetary and fiscal policy. The dovish central bank puts greater emphasis on output stabilization, thus responds only weakly to inflation to keep the balance between output and inflation stability. Reflecting this view, the (long run) coefficients on inflation (ϕ_π) and on the output (ϕ_y) are set to 0.83 and 0.27, respectively, while the interest rate smoothing parameter (ψ_r) is assumed to be 0.68. These values are based on the work of Clarida et al. (2000) for the pre-Volcker era that ends right before Paul Volcker took office as the new Federal Reserve chairman in $1979Q3$. Government spending is assumed not to respond to the government debt, that is, γ_g is set to 0 implying that the fiscal authority also implements their stimulus policies aggressively.

In regime H, however, the hawkish central bank prioritizes keeping inflationary pressure in check, which results in more aggressive responses to the inflation gap, conflicting with the fiscal stimulus of the government. For this specification, we employ the parameter values from Clarida et al. (2000) for the post-Volcker era. That is, we set ϕ_π, ϕ_y, and ψ_r to 2.15, 0.93, and 0.79, respectively. The fiscal authority in regime H maintains a less dovish stance than its stance in regime D, implementing mildly expansionary fiscal policy with $\gamma_g = 0.07$. We assume $\rho_g = 0.8$ and $\sigma_g = 0.01$ for the stochastic process of the government spending shock in (1.18) in both regimes.

Table 1.1: Parameter Calibrations

Preference and HHs	
β, discount factor	0.9958
h, habit formation	0.99
η, inverse Frisch labor elas.	2
$\bar{n}$, steady-state labor	1/3
δ, depreciation rate	0.025
α_g, subs. of private/public cons.	-0.2
Frictions and Production	
α, capital share	0.33
θ_p, elas. of subs. b/w intermediate goods	8
θ_w, elas. of subs. b/w different types of labor	8
ω_p, Calvo price stickiness	0.8
ω_w, Calvo wage stickiness	0.8
ζ_2, capital utilization	0.15
κ, investment adj. cost	5
Monetary/Fiscal Calibrations	
$\bar{\pi}$, steady-state gross inflation rate	1.0082
ψ_g, lagged resp. for govt spending	0.98
s_g, steady-state govt spending-to-GDP ratio	0.0945
s_b, steady-state debt-to-GDP ratio	1.3707
$\bar{\tau}^n$, steady-state labor tax rate	0.2171
$\bar{\tau}^k$, steady-state capital tax rate	0.2497
Regime D	
Monetary Policy	
ϕ_π, interest rate resp. to inflation	0.83
ϕ_y, interest rate resp. to output	0.27
ψ_r, resp. to lagged interest rate	0.68
Fiscal Policy	
γ_g, govt spending resp. to debt	0
Regime H	
Monetary Policy	
ϕ_π, interest rate resp. to inflation	2.15
ϕ_y, interest rate resp. to output	0.93
ψ_r, resp. to lagged interest rate	0.79
Fiscal Policy	
γ_g, govt spending resp. to debt	0.07
Shocks	
ρ_g, govt spending persistence	0.8
σ_g, govt spending	0.01

Note: Parameters are calibrated at a quarterly frequency.

1.3.2 Simulation Results

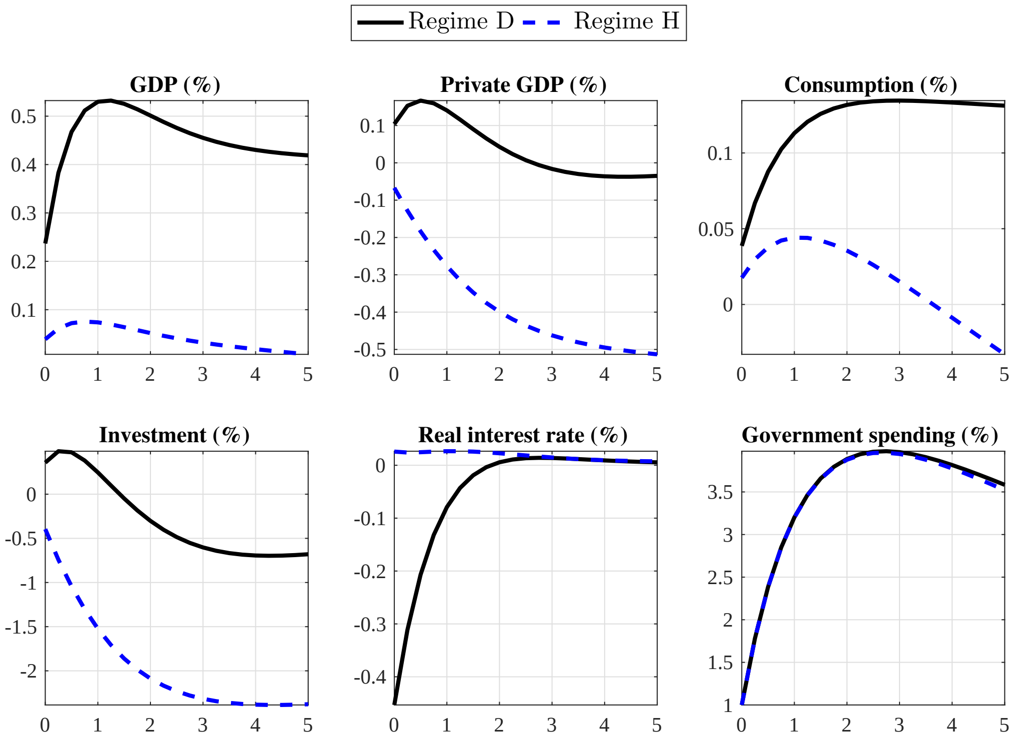
This subsection reports simulated impulse-response functions (IRFs) of key macroeconomic variables to positive government spending shocks under the two regimes, regime D (solid) and regime H (dashed), in Figure 1.1.

We observe persistently positive output effects of fiscal policy only in regime D, where the monetary authority maintains a dovish monetary policy stance in collaboration with the fiscal stimulus. Output and inflation both rise in response to the government spending shock, but the central bank raises the interest rate at a slower rate than inflation, resulting in a decrease in the real interest rate for about two years. Responses of the private GDP also stay positive in the first two years until persistently positive consumption responses are dominated by the negative response of investment. The total GDP exhibits persistent, solid positive responses even when the private GDP responds negatively after the first two years, which implies that responses of public (government) spending dominate those of the private GDP.

On the other hand, we obtained substantially weaker output effects of fiscal policy in regime H, which sharply contrast with those in regime D. In response to the government spending shock, inflation rises slower than the nominal interest rate as the central bank raises the interest rate aggressively to curb inflation, maintaining a hawkish policy stance. Consequently, the real interest rate rises, crowding out investment, which results in immediate decreases in the private GDP. Private consumption responds positively, reflecting the complementarity between government spending and consumption. However, its positive responses are dominated by decreases in investment, which result in negative responses of the private GDP. The total GDP rises in the short-run driven by increases in government spending, but eventually falls below zero due to substantial negative responses of the private GDP.

Overall, our simulation results clearly demonstrate that the effectiveness of fiscal policy greatly hinges upon the coordination of monetary and fiscal policies. In the next section, we report strong empirical evidence of time-varying output effects of fiscal policy in the private sector using the post-war U.S. macroeconomic data. We found a very limited role of the real interest rate in the propagation mechanism of fiscal policy, which is at odds with the simulation results from our baseline New Keynesian model presented in this section. In what follows, we suggest a sentiment channel as an alternative to the real interest rate channel.

Figure 1.1: Simulated Impulse Responses to the Government Spending Shock



Note: We report simulated responses over 5 years to a 1% government spending shock in each regime. The monetary authority is assumed to maintain an accommodative stance that coordinates well with expansionary fiscal policy under the Regime D. On the other hand, the central bank maintains a hawkish policy stance that conflicts the dovish stance of the government under the Regime H.

1.4 The Empirics

This section presents our baseline empirical model for the U.S. post-war macroeconomic data. We report solid empirical evidence that supports time-varying output effects of fiscal policy.

1.4.1 The Empirical Model

We employ the following vector autoregressive (VAR) process of order p.

$$\mathbf{x}_t = \gamma' \mathbf{d}_t + \sum_{j=1}^{p} \mathbf{A}_j \mathbf{x}_{t-j} + \mathbf{C}\varepsilon_t, \quad (1.20)$$

where

$$\mathbf{x}_t = [g_t \;\; y_t \;\; \mathbf{z}_t]',$$

$\mathbf{d}_t$ is a vector of deterministic terms that includes an intercept and up to quadratic time trend. $\mathbf{C}$ denotes a lower-triangular matrix and ε_t is a vector of mutually orthonormal structural shocks, that is, $E\varepsilon_t\varepsilon_t^{'} = \mathbf{I}$. We are particularly interested in the j-period ahead orthogonalized impulse-response function (IRF) defined as follows.

$$IRF_{k,j} = E\left(\mathbf{x}_{t+j}|\varepsilon_{k,t} = 1, \Omega_{t-1}\right) - E\left(\mathbf{x}_{t+j}|\Omega_{t-1}\right), \tag{1.21}$$

where $\varepsilon_{k,t}$ is the structural shock to the k^{th} variable in (1.20) that occurs at time t. Ω_{t-1} is the adaptive information set at time $t-1$, that is, $\Omega_j \supseteq \Omega_{j-1}, \forall j$.

g_t denotes federal government spending, which is used to identify the fiscal policy shock. We employ discretionary components of government spending, that is, federal consumption expenditures and gross investment. Following Blanchard and Perotti (2002), g_t is ordered first in $\mathbf{x}_t$, meaning that g_t is not contemporaneously affected by innovations in other variables within one quarter. This assumption is frequently employed in the current literature, because implementations of discretionary fiscal policy actions require Congressional approvals, which normally take more than one quarter.[9]

y_t is the real per capita gross domestic product (GDP), but we also consider the private real GDP per capita ($pgdp_t$) for y_t to measure the stimulus effects of fiscal policy on private activity. In addition, we directly employ private spending variables for y_t such as private consumption ($conm_t$) and private investment ($invt_t$).

$\mathbf{x}_t$ includes a vector of control variables from the money market $\mathbf{z}_t = [int_t \;\; mon_t]'$, where int_t is the effective federal funds rate and mon_t is the log monetary base. These variables are ordered in the last block, because the Federal Open Market Committee (FOMC) can revise the stance of monetary policy whenever policy-makers deem it necessary by holding regular and

[9]Kim and Jia (2017) employed the government total expenditures that includes transfer payments in addition to the discretionary government consumption and investment spending. Since transfer payments have automatic stabilizers, they put g_t next to y_t.

emergency meetings. Note that int_t is ordered before mon_t, because the Fed targets the interest rate, while the monetary base changes endogenously.

It is well known that econometric inferences from recursively identified VAR models may not be robust to alternative VAR ordering. It turns out that our empirical findings are not subject to such criticism as long as we are interested in the IRFs to the government spending (g_t) shock, $IRF_{1,j}$. Given the location of g_t, $IRF_{1,j}$ is *numerically identical* even if all variables next to g_t are randomly re-shuffled. See Christiano et al. (1999) for details.[10]

1.4.2 Data Descriptions

We obtained most data from the Federal Reserve Economic Data (FRED) website. Observations are quarterly frequency and span from $1960Q1$ to $2017Q3$.

g_t is federal consumption expenditures and gross investment (FGCE), which constitutes *discretionary* components of federal government expenditures. The private GDP ($pgdp_t$) is the total GDP (gdp_t; NGDP) minus total (federal and state & local) government consumption expenditures and gross investment (GCE). Consumption ($conm_t$) is total personal consumption expenditures on nondurables (PCND) and services (PCESV). Investment ($invt_t$) denotes private nonresidential fixed investment (PNFI). All spending variables are expressed in real per capita terms. That is, they are divided by the GDP deflator (GDPDEF) and by the civilian noninstitutional population (CNP16OV), then log-transformed.

The nominal interest rate (int_t) is the effective federal funds rate (FEDFUNDS) divided by 100, which can be used to identify the monetary policy shock.[11] mon_t is the monetary base (BOGMBASE), expressed in natural logarithm. We also employ the *ex post* real interest rate in our VAR models, which equals int_t minus the consumer price index (CPIAUCSL) based inflation.

Later, we augment our benchmark VAR model (1.20) with the (log) Index of Consumer Expectations ($sent_t$) to investigate the propagation mechanism of fiscal policy through sentiment. We obtained $sent_t$ from the University of Michigan's Survey of Consumers database.

[10] Similarly, all response functions to monetary policy shocks are robust to alternative ordering given the location of monetary variables, int_t and mon_t.

[11] We observed no evidence of structural breaks in the output effects of monetary policy. Results are available upon requests.

$sent_t$ provides information on the level of consumer confidence about economic conditions in the near future. In addition to this forward-looking sentiment index, we experimented with the Current Conditions Index and the Index of Consumer Sentiment (combined index), obtained from the same source. All three indices are highly correlated with each other, thus yield qualitatively similar empirical results.[12]

Also, we use the Survey of Professional Forecasters (SPF) data to understand how market participants revise their forecasts of key macroeconomic variables. The median SPF forecasts data for relevant variables were obtained from the Philadelphia Fed website for the period between $1968Q4$ and $2017Q3$. [13] There were 9 changes in the base year in the National Income and Product Account (NIPA) during this sample period. Some authors (Ramey (2011b); Forni and Gambetti (2016)) used growth rates of the SPF forecasts without adjusting for changes in the base year, which generates 9 outlier observations in the data. To prevent this, we re-scaled all relevant forecast data so that they are expressed in 2009 dollar terms.

It should be noted that forecasters were asked to predict *nominal* defense spending until $1981Q2$.[14] Since then, they were asked to predict *real* federal consumption expenditures and gross investment. Following Ramey (2011b), we used the GDP deflator median forecasts to convert nominal defense spending forecasts to real defense spending forecasts. We combine the real defense spending forecasts with the real federal spending growth forecasts in order to acquire the data for reasonably long sample period. This seems to be a fairly good approximation for the growth rate forecasts, because they tend to exhibit high degree comovements.[15] Ramey (2011b) also employed a similar approach. In what follows, we study how market agents reformulate their forecasts for the output growth, $y_{t+j}^{SPF} - y_{t-1}^{SPF}$ when they revise the forecasts of government spending growth, $g_{t+j}^{SPF} - g_{t-1}^{SPF}$.[16]

[12] All results are available from authors upon request.

[13] The mean SPF forecasts yielded qualitatively similar results.

[14] We thank Tom Stark at the Philadelphia Fed who kindly provided us nominal defense spending data from $1968Q4$ to $1981Q2$, which are not available on the SPF website.

[15] Results are available upon requests from authors.

[16] We assume these forecasts are formulated utilizing the information set at time $t-1$, since the current period data such as y_t and g_t are not known at time t. Note that forecasters are asked to predict, or nowcast, y_t and g_t. Note also that forecasters are asked to predict the values at time $t-1$ (previous period) because these values are subject to revisions, although their predictions normally stay the same from the previous period.

1.4.3 Empirical Findings

The Weakening Effectiveness of Fiscal Stimulus

This section reports an array of the impulse-response function ($IRF_{1,j}$) estimates to a positive 1% structural shock to government spending (g_t) as described in (1.20) and (1.21). We also report 90% confidence intervals obtained from 500 nonparametric bootstrap simulations using the empirical distribution.[17] Our findings below demonstrate that the output effects of fiscal stimulus have become substantially weaker over time.

Figures 1.2 and 1.3 present the responses of the GDP (gdp_t) and the private GDP ($pgdp_t$), respectively, to the expansionary government spending shock from a quad-variate VAR with $\mathbf{x}_t = [g_t \;\; gdp_t(pgdp_t) \;\; int_t \;\; mon_t]'$. Specifically, figures in the panel (a) are based on the first 30-year sample period (SP1), $1960Q1$ to $1989Q4$, while the last 30-year sample period (SP2), $1987Q4$ to $2017Q3$, was used to generate the IRFs in the panel (b).

It should be noted that the output responses from these sub-sample periods are *qualitatively* different. The IRF point estimates of the total GDP and the private GDP to the government spending shock are well above zero in SP1 ($1960Q1 - 1989Q4$), whereas their responses have become substantially muted when we employ data in SP2 ($1987Q4 - 2017Q3$). Putting it differently, both output responses remain positive for a prolonged period of time in SP1, but their responses become overall negative in SP2. We also note that the private GDP never respond positively to the shock in SP2, implying that initial positive responses of the total GDP simply reflect increases in government spending.

These IRFs imply the possibility of the time-varying effectiveness of fiscal policy in stimulating private activity ($pgdp_t$). In other words, the government spending shock seems to have promoted private spending in SP1 but not in SP2.

Motivated by these findings, we further investigate such possibility via repeated VAR model estimations with a fixed-size rolling window scheme described as follows. We use the rolling-window scheme instead of recursive schemes because we are interested in detecting structural changes in the data generating process of $\mathbf{x}_t$.

[17] The 5^{th} and 95^{th} percentiles of the 500 response function estimates constitute the 90% confidence interval.

We begin with an estimation of the VAR model using the first $T_0(< T)$ observations, $\{\mathbf{x}_t\}_{t=1}^{T_0}$. After obtaining the first round set of IRF estimates, we move the sample period window forward by one. That is, new observations at time $T_0 + 1$ ($\mathbf{x}_{T_0+1}$) are added to the sample, but we drop the oldest ones at time $t = 1$ ($\mathbf{x}_1$) to maintain the same size of the sample window. Using $\{\mathbf{x}_t\}_{t=2}^{T_0+1}$, we estimate the second round set of IRFs. We repeat until we obtain the last round IRFs using $\{\mathbf{x}_t\}_{t=T-T_0+1}^{T}$, totalling $T - T_0 + 1$ sets of the IRF estimates.

We report our estimates with a 30-year ($T_0 = 120$ quarters) fixed-size rolling window in the lower panel of Figures 1.2 and 1.3 for the GDP variables.[18] The range of the x-axis (Date) is from $1989Q4$ to $2017Q3$, where the fine grid points indicate the ending period of each rolling window. The y-axis (Year) is the time horizon (j) of the response function indexed from 0 to 5 years. The z-axis is the response ($IRF_{1,j}$) of each variable to a 1% government spending shock.

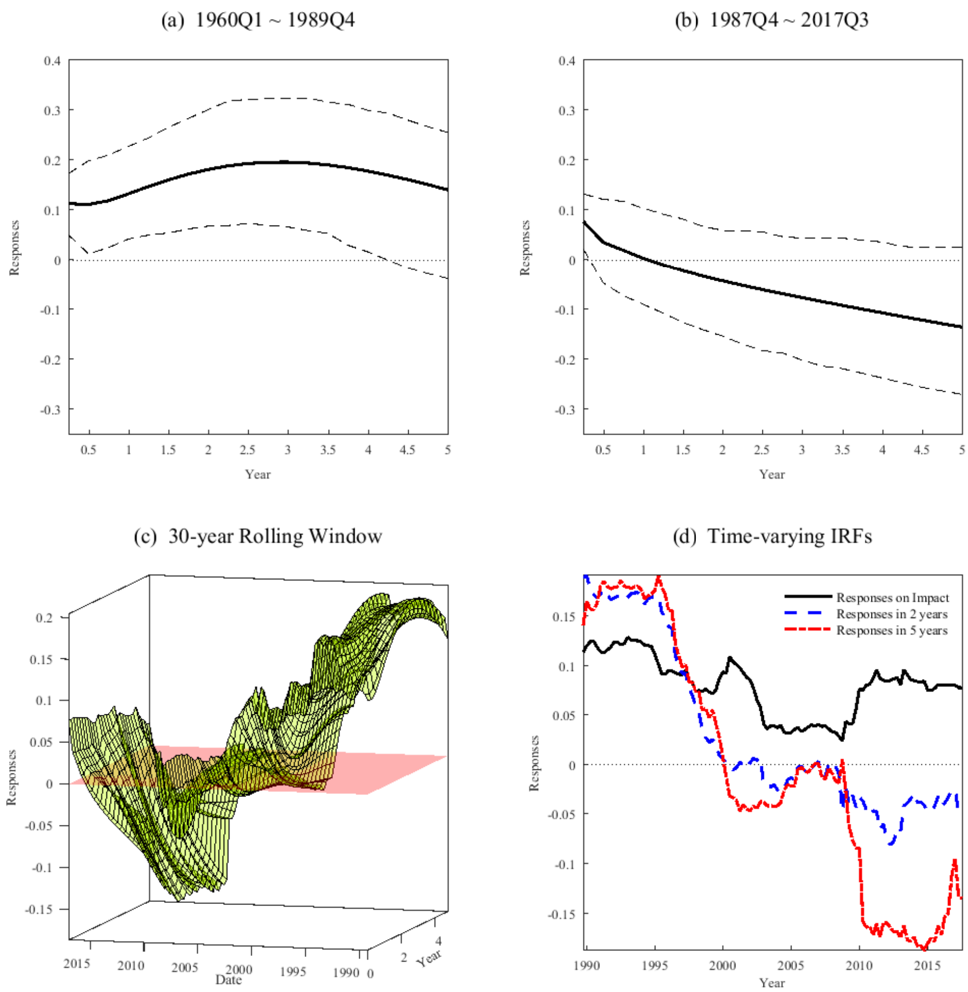
The surface graphs in the panel (c) of Figures 1.2 and 1.3 reveal dramatic decreases in the responses of gdp_t and $pgdp_t$ over time, respectively. Strong positive responses of the GDP variables are rapidly dragged down as more observations are added from later sample periods.

It should be noted that the responses of the private GDP become substantially negative, pushing the total GDP responses toward a negative region, which implies that the weakening stimulus effects of fiscal policy are mainly driven by time-varying responses of private spending.

To highlight these transitions over time, in panel (d) of Figures 1.2 and 1.3, we report the responses of the output variables in the short-run to the long-run by dissecting the surface graphs at $y = 0,\ 2,\ 5$ (years) of the y-axis from the right to the left. Contemporaneous responses (impact; $y = 0$) of gdp_t and $pgdp_t$ do not exhibit substantial variations over time, while the responses in 2 years and in 5 years clearly show a downward trend, implying the substantially diminished effects of fiscal stimulus over time. It is also interesting to see that positive responses of gdp_t on impact ($y = 0$) are due to increases in g_t itself because $pgdp_t$ barely responds when the shock occurs.

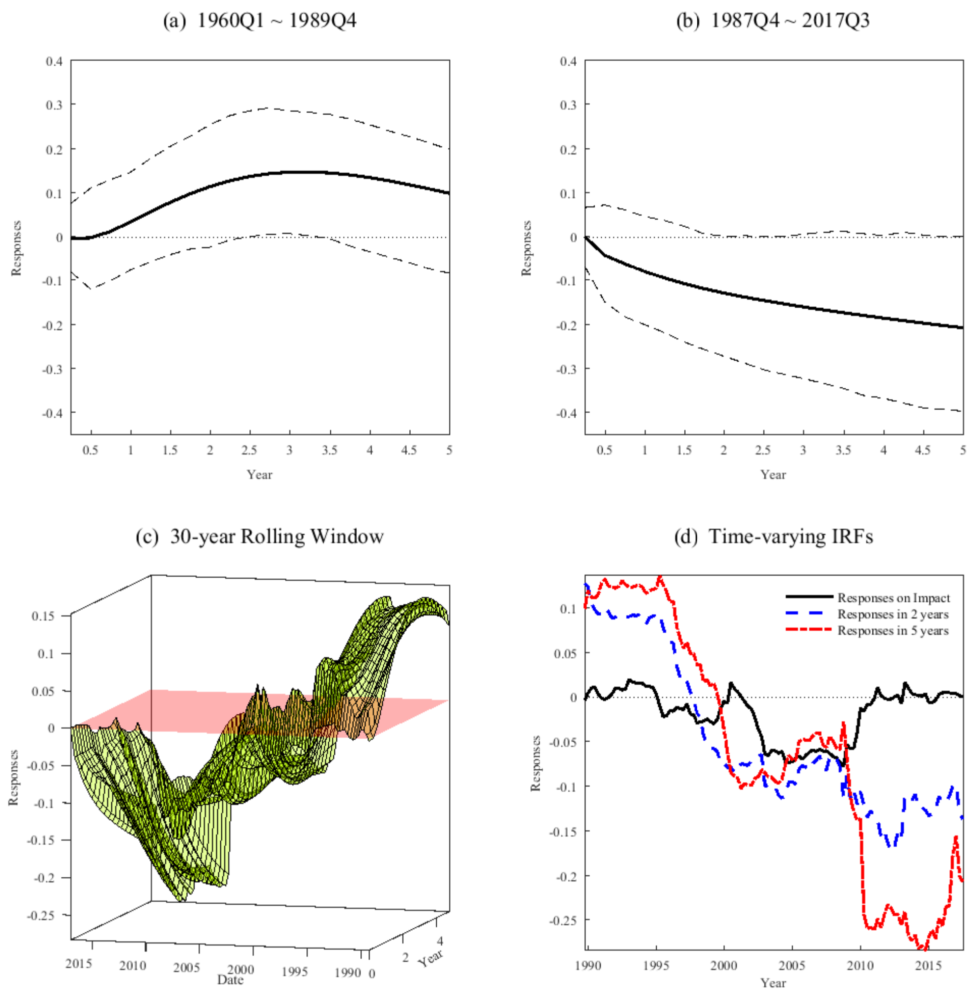
[18] We also implemented the same analysis with a 20-year window as well as a 40-year window scheme. Results are overall similar and are available upon requests.

Figure 1.2: GDP Responses to the Government Spending Shock



Note: We report the impulse-response function (IRF) estimates from $\mathbf{x}_t = [g_t, gdp_t, int_t, mon_t]'$ to a 1% government spending shock. Panel (a) and Panel (b) report the IRF estimates (solid) of the total GDP along with its 90% confidence bands (dashed) that were obtained from 500 bootstrap simulations with empirical distributions. Panel (c) reports an array of IRFs to the government spending shock with a 30-year fixed-size rolling window scheme. Panel (d) provides the IRFs in the short- to the long-run by dissecting the surface graph (panel (c)) at $y = 0,\ 2,\ 5$ (years) of the year-axis.

Figure 1.3: Private GDP Responses to the Government Spending Shock



Note: We report the impulse-response function (IRF) estimates from $\mathbf{x}_t = [g_t, pgdp_t, int_t, mon_t]'$ to a 1% government spending shock. Panel (a) and Panel (b) report the IRF estimates (solid) of private GDP along with its 90% confidence bands (dashed) that were obtained from 500 bootstrap simulations with empirical distributions. Panel (c) reports an array of IRFs to the government spending shock with a 30-year fixed-size rolling window scheme. Panel (d) provides the IRFs in the short- to the long-run by dissecting the surface graph (panel (c)) at $y = 0,\ 2,\ 5$ (years) of the year-axis.

Observing these remarkably dramatic changes in private GDP responses over time, we further look into the source of these transitions by investigating the IRFs of the two private spending variables, consumption ($conm_t$) and investment ($invt_t$). The IRF estimates with $\mathbf{x}_t = [g_t \;\; conm_t(invt_t) \;\; int_t \;\; mon_t]'$ are reported in Figures 1.4 and 1.5, respectively.

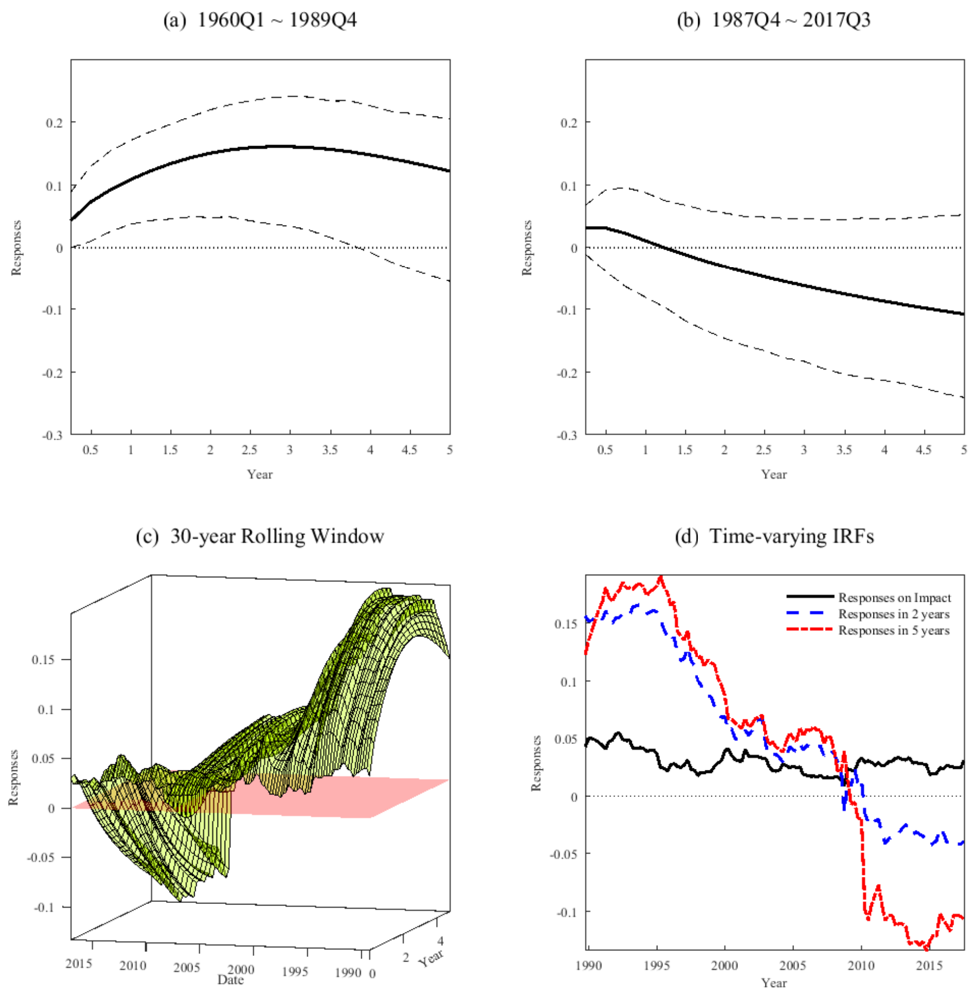
We note a close resemblance between consumption ($conm_t$) responses and those of the private GDP ($pgdp_t$) as can be seen in Figure 1.4. Consumption increases greatly and significantly over time when g_t shock occurs in SP1. In SP2, however, consumption responses continue to fall to a negative region, although we still observe a weak but positive responses in the very short-run. The surface graph in the panel (c) confirms rapid deteriorations of the consumption responses over time. The panel (d) graph also shows a clear downward trend of the responses of consumption to the spending shock in the medium-run and in the long-run.

On the other hand, investment ($invt_t$) responds overall negatively to the government spending shock as can be seen in Figure 1.5, although negative responses of $invt_t$ tend to go deeper as the sample period moves forward.[19] These findings are confirmed by the downward trend in the IRFs in the medium-run as well as in the long-run, whereas initial responses are overall negligible as can be seen in Figure 1.5(d).

These IRF analyses provide strong evidence that fiscal stimulus has become less effective in stimulating private spending. The positive responses of the private GDP in earlier sample periods are mostly driven by rising consumption given overall negative responses of investment to the shock. On the contrary, fiscal policy has become dramatically ineffective over time. The private GDP ($pgdp_t$) responds mostly negatively to the government spending shock when more recent sample periods are employed, generating completely ineffective stimulus effects of fiscal policy.

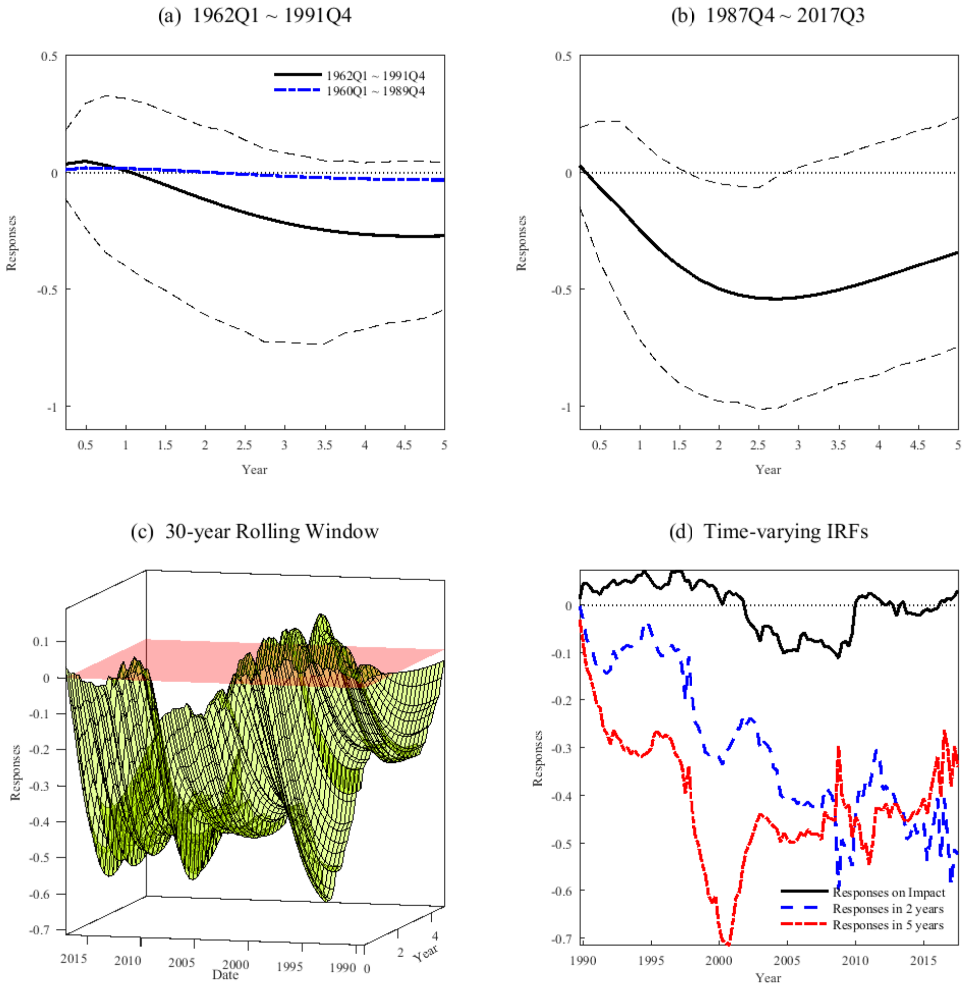
[19] We obtain negligible responses of $invt_t$ from the first 30-year sample period, $1960Q1$˜$1989Q4$. These seem to be outliers because we obtained qualitatively similar negative responses by shifting the window by just a few years such as $1962Q1$˜$1991Q4$.

Figure 1.4: Consumption Responses to the Government Spending Shock



Note: We report the impulse-response function (IRF) estimates from $\mathbf{x}_t = [g_t, conm_t, int_t, mon_t]'$ to a 1% government spending shock. Panel (a) and Panel (b) report the IRF estimates (solid) of consumption along with its 90% confidence bands (dashed) that were obtained from 500 bootstrap simulations with empirical distributions. Panel (c) reports an array of IRFs to the government spending shock with a 30-year fixed-size rolling window scheme. Panel (d) provides the IRFs in the short- to the long-run by dissecting the surface graph (panel (c)) at $y = 0,\ 2,\ 5$ (years) of the year-axis.

Figure 1.5: Investment Responses to the Government Spending Shock



Note: We report the impulse-response function (IRF) estimates from $\mathbf{x}_t = [g_t, invt_t, int_t, mon_t]'$ to a 1% government spending shock. Panel (a) and Panel (b) report the IRF estimates (solid) of investment along with its 90% confidence bands (dashed) that were obtained from 500 bootstrap simulations with empirical distributions. Panel (c) reports an array of IRFs to the government spending shock with a 30-year fixed-size rolling window scheme. Panel (d) provides the IRFs in the short- to the long-run by dissecting the surface graph (panel (c)) at $y = 0,\ 2,\ 5$ (years) of the year-axis.

Assessing the Role of the Interest Rate under Different Regimes

This subsection empirically assesses the role of the interest rate channel of expansionary fiscal policy shocks under different policy regimes described earlier in our theoretical models. Section 1.3 demonstrates that government spending shocks generate persistent stimulus effects on private spending only in regime D when the monetary policy stance stays accommodative. The nominal interest rate rises slower than the inflation rate, resulting in decreases in the real interest rate, which stimulate private investment as well as consumption.

On the other hand, the nominal interest rate rises faster than the inflation rate in regime H as the central bank maintains its hawkish policy stance to suppress inflationary pressure. The real interest rate rises, which decreases private investment substantially, dominating positive responses of consumption in the short-run. Therefore, fiscal policy fails to stimulate private activity in regime H.

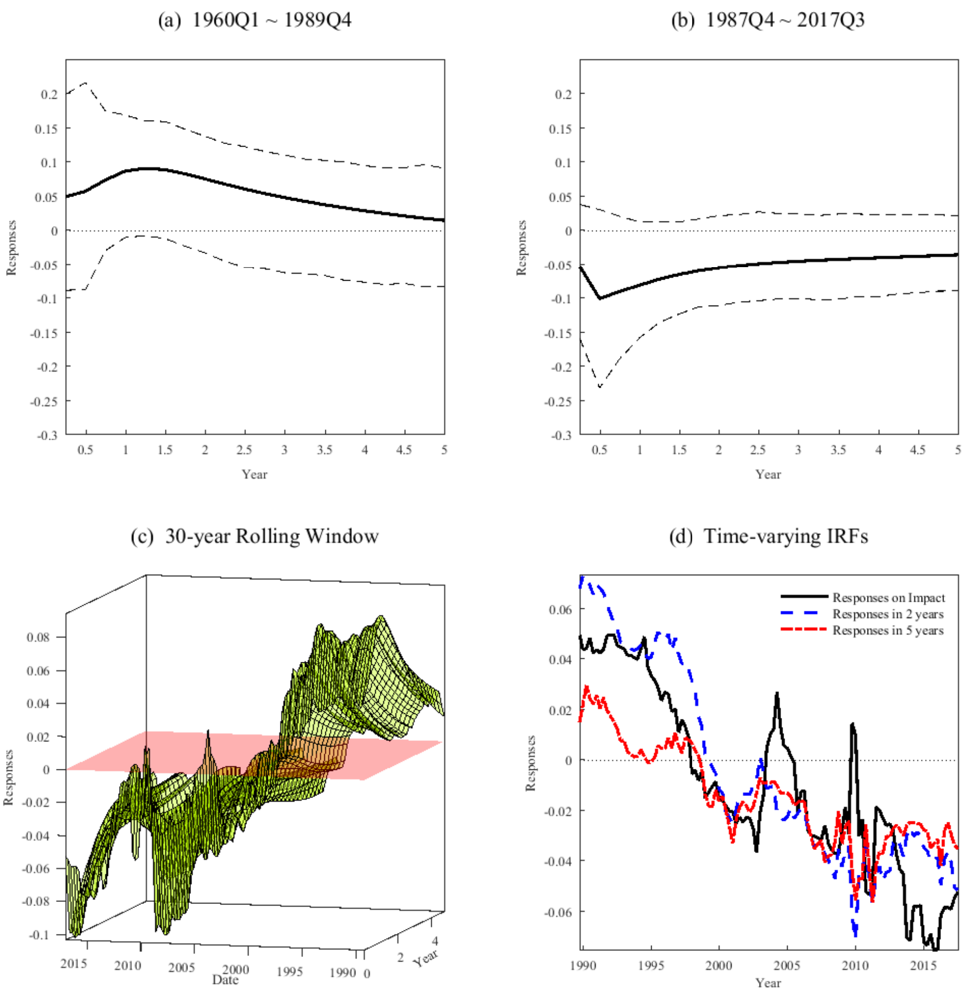
The U.S. post-war data seems to be overall consistent with the theoretical predictions on the output effects of fiscal policy. However, the data shows a very limited role of the interest rate in the transmission mechanism of fiscal policy. For this purpose, we consider the VAR model (1.20) with $\mathbf{z}_t = [rffr_t \ \ mon_t]'$, where $rffr_t$ is the *ex-post* real federal funds rate (FEDFUNDS) accompanied by the log-transformed monetary base. We used the CPI-based inflation rate to obtain the *ex-post* inflation.

Clarida et al. (2000) demonstrated that the Fed had remained dovish (accommodative) during the pre-Volcker era ($1960Q1 - 1979Q2$), while it had switched to a hawkish monetary policy stance after Paul Volcker's tenure began in the third quarter of 1979. With the Taylor rule parameter estimates from their work, the New Keynesian model predicts the real interest rate to rise in response to the government spending shock in regime H (post-Volcker era), while it is expected to decline in regime D (pre-Volcker era).

We report empirical evidence that is at odds with these predictions. As can be seen in Figure 1.6, $rffr_t$ positively responds to the fiscal shock in SP1 ($1960Q1 - 1989Q4$), while it responds negatively in SP2 ($1987Q4 - 2017Q3$). Also, the IRFs of $rfft_t$ from the rolling window scheme in the panel (c) and (d) clearly demonstrate a downward trend in all horizons.

Recall private investment tends to decline in response to the government spending shock in both regimes. Note that both $rffr_t$ and $invt_t$ decline in response to the fiscal shock in SP2. This implies that private investment must have *shifted* to the left by *exogenous* factors rather than endogenously responding to changes in the real interest rate. We introduce a sentiment channel to explain this possibility of exogenous factors in the next section.

Figure 1.6: Real FFR Responses to the Government Spending Shock



Note: We report the impulse-response function (IRF) estimates from $\mathbf{x}_t = [g_t, gdp_t, rint_t, mon_t]'$ to a 1% government spending shock. Panel (a) and Panel (b) report the IRF estimates (solid) of real interest rate along with its 90% confidence bands (dashed) that were obtained from 500 bootstrap simulations with empirical distributions. Panel (c) reports an array of IRFs to the government spending shock with a 30-year fixed-size rolling window scheme. Panel (d) provides the IRFs in the short- to the long-run by dissecting the surface graph (panel (c)) at $y = 0,\ 2,\ 5$ (years) of the year-axis.

Fiscal Policy Effects on Sentiment

The role of sentiment as one of potential drivers of macroeconomic fluctuations has long been discussed in the current literature. Hall (1993) and Blanchard (1993), among others, emphasize the causal effects of animal spirit on economic activity, whereas Cochrane (1994) claims that consumer confidence reflects news about changes in economic productivity in the future, which creates a close link between innovations in consumer confidence and subsequent variations in economic activity.

Using a nonlinear state-dependent VAR model, Bachmann and Sims (2012) suggest that the government spending shock can trigger consumer optimism during times of slack, which results in a high fiscal multiplier during recessions. On the other hand, Kim and Jia (2017) demonstrate that the shock is likely to generate consumer *pessimism* in all phases of business cycle when properly detrended data are used.

Recognizing a potentially important role of sentiment, we shift our attention from state-dependent nonlinearity to a time-dependent stochastic process because sentiment responses seem to change over time. For this purpose, we estimate and report the time-varying dynamic adjustments of sentiment in response to the government spending shock, utilizing the VAR model (1.20) with $\mathbf{z}_t = [int_t \;\; mon_t \;\; sent_t]'$. Recall that the location of $sent_t$ in the VAR does not matter for the fiscal policy effects as long as $sent_t$ is placed next to g_t. See Christiano et al. (1999) for detailed explanations on this property.

Figure 1.7 clearly shows qualitatively different responses of sentiment over time. Sentiment ($sent_t$) responds positively to the government spending shock in SP1 ($1960Q1-1989Q4$), while the shock generates consumer pessimism in SP2 ($1987Q4 - 2017Q3$). The figures in the lower panel exhibit a downward trend especially in the two-year and in the five-year sentiment responses, while a long swing is observed in the contemporaneous responses on impact.

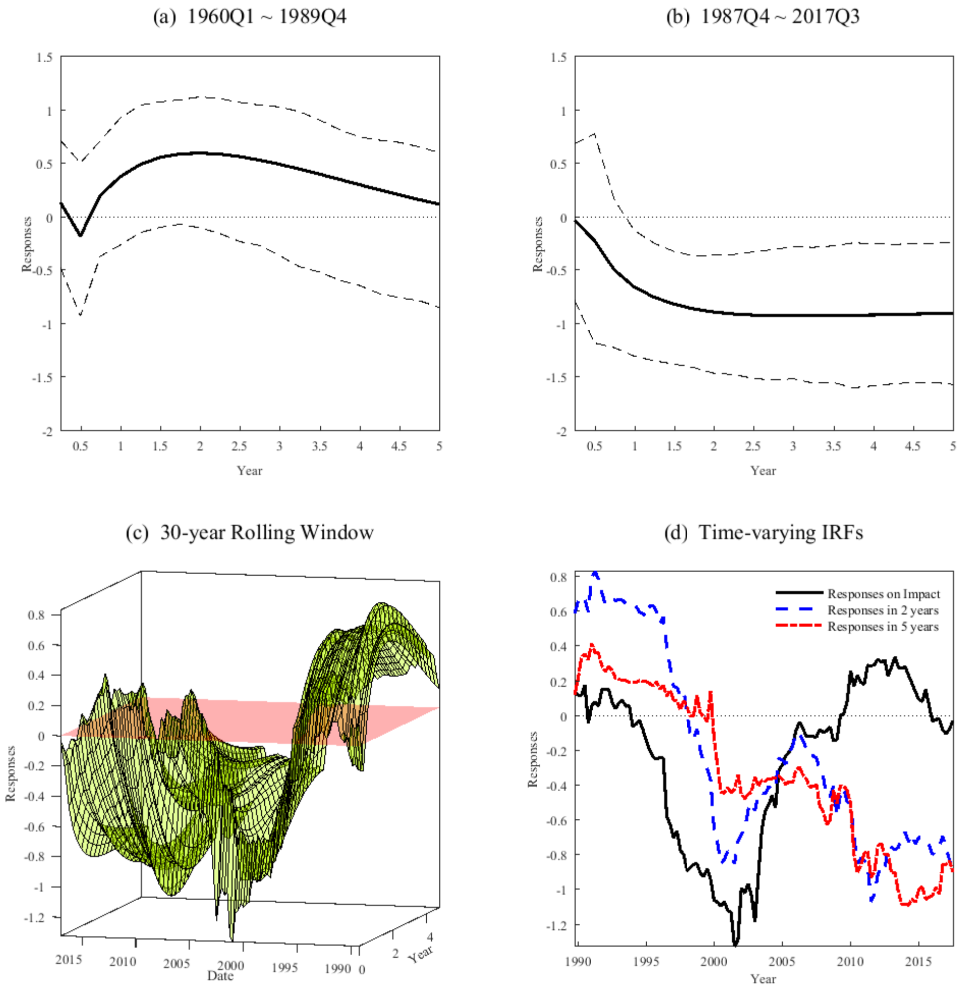
We consider these changes in the response function of $sent_t$ as a clue to understand why the output effects of fiscal stimulus have become weaker over time. Significant stimulating effects of fiscal policy during earlier sample periods are consistent with consumer optimism that results from the government spending shock. On the other hand, it tends to generate consumer pessimism with later observations, decreasing not only investment but also consumption.[20]

One possible criticism against this view is the following. Sentiment may simply reflect changes in consumption rather than leading it. This doesn't seem to be the case especially in SP2. As can be seen in Figure 1.4(b), consumption initially responds positively for a while when the government spending shock occurs, whereas sentiment starts deteriorating immediately in Figure 1.7(b). That is, pessimism goes deeper since the impact of the shock. If $sent_t$ simply reflects the changes in $conm_t$, sentiment must have risen at least in the short-run because consumption rises in the short-run. Therefore, sentiment seems to be leading the innovations in consumption rather than passively reflecting innovations in consumption.

In what follows, we implement counterfactual simulation exercises to provide some insights on the importance of this sentiment channel in propating government spending shocks to private activity.

[20]It might be the case that large sudden increases in government spending are perceived as a confirmation of an incoming recession in near future, generating consumer pessimism, which then results in a decrease in private spending.

Figure 1.7: Sentiment Responses to the Government Spending Shock



Note: We report the impulse-response function (IRF) estimates from $\mathbf{x}_t = [g_t, gdp_t, rint_t, mon_t, sent_t]'$ to a 1% government spending shock. Note that the location of $sent_t$ is irrelevant given that g_t is placed first. Panel (a) and Panel (b) report the IRF estimates (solid) of sentiment along with its 90% confidence bands (dashed) that were obtained from 500 bootstrap simulations with empirical distributions. Panel (c) reports an array of IRFs to the government spending shock with a 30-year fixed-size rolling window scheme. Panel (d) provides the IRFs in the short- to the long-run by dissecting the surface graph (panel (c)) at $y = 0,\ 2,\ 5$ (years) of the year-axis.

Counterfactual Simulation Exercises

This section implements counterfactual simulation exercises employing the 5-variate VAR model used in the previous section, $\mathbf{x}_t = [g_t \;\; y_t \;\; int_t \;\; mon_t \;\; sent_t]'$. The primary purpose of this exercies is to quantitatively measure the importance of the sentiment channel in the propagation of government spending shocks.

Following Bachmann and Sims (2012), we generate a hypothetical sequence of sentiment shocks that holds sentiment unchanged at all forecast horizons since the impact of the fiscal shock. Putting it differently, we eliminate the indirect output effects of the government spending shock through changes in sentiments that were triggered by the shock. In doing so, one can obtain the hypothetical direct fiscal spending shock effects on private activity.

Our model specification is more general than that of Bachmann and Sims (2012), $\mathbf{x}_t = [g_t \;\; sent_t \;\; y_t]'$, in the sense that our system comes with monetary control variables in $\mathbf{z}_t$. Furthermore, we allow sentiment to reflect innovations of all other variables by having $sent_t$ ordered last.[21]

Let $\bar{F}$ denotes the top-left 5 by 5 sub-matrix of the $5p$ by $5p$ companion matrix for the state-space representation. The h-period ahead impulse-response function of the i^{th} variable to the structural shock to the j^{th} variable is given by the following.

$$\psi_{i,j}\left(h\right) = s_i^{'}\bar{F}^{h-1}A_0^{-1}s_j, \tag{1.22}$$

where s_i is a 5 by 1 selection vector, $[\mathbf{0}' \; 1 \; \mathbf{0}']'$, where 1 is the i^{th} component.

The contemporaneous sentiment response to a 1% government spending shock ($u_1^g = 1$) is given by $s_5^{'}A_0^{-1}s_1$. To cancel out this response, we generate the following hypothetical sentiment shock,

$$u_1^{sent} = -\frac{s_5^{'}A_0^{-1}s_1}{s_5^{'}A_0^{-1}s_5}, \tag{1.23}$$

[21] However, we obtained qualitatively similar results that are available upon request.

We recursively calculate the sequence of sentiment shocks for the remaining period as follows.

$$u_h^{sent} = -\frac{s_5' \bar{F}^{h-1} A_0^{-1} s_1 + \sum_{r=1}^{h-1} \left(s_5' \bar{F}^{h-r} A_0^{-1} s_5 \right) u_r^{sent}}{s_5' A_0^{-1} s_5}, \; h = 2, 3, ... \tag{1.24}$$

Finally, we obtain the counterfactual impulse-response function of the i^{th} variable to the 1% fiscal spending shock by the following.

$$\hat{\psi}_{i,1}(h) = \psi_{i,1}(h) + \sum_{r=1}^{h} \left(s_i' \bar{F}^{h-r} A_0^{-1} s_5 \right) u_r^{sent}, \tag{1.25}$$

where $\psi_{i,1}(h)$ is the unrestricted h-period ahead impulse-response function.

Figure 1.8 reports estimated hypothetical response functions (solid lines) $\hat{\psi}_{i,1}(h)$. Dashed lines are unconstrained impulse-response functions $\psi_{i,1}(h)$ and their 90% confidence bands from 500 nonparametric bootstrap simulations. As can be seen at the bottom, sentiment responses are completely muted (solid lines) after we add the sequence of hypothetical sentiment shock in (1.23) and (1.24).

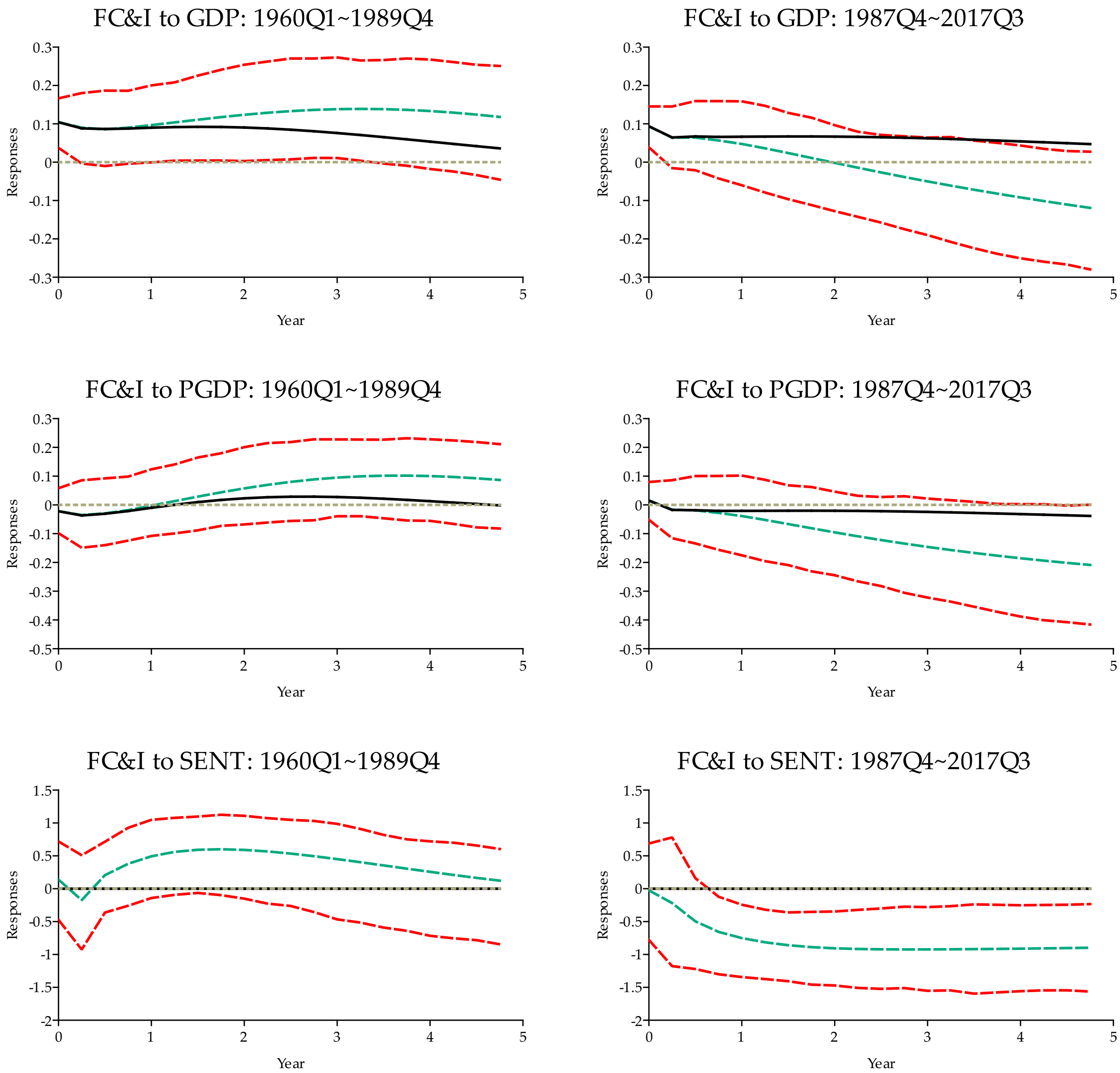
It should be noted that the structural break in the output responses we previously observed has disappeared after we control the endogenous responses of sentiment. Specifically,

1. The private GDP hardly responds to the government spending shock once we neutralize the indirect sentiment effect. That is, we observe virtually no direct effects of fiscal spending shocks on the private GDP ($pgdp_t$), implying that positive (or negative) output responses in the private sector have been driven by changes in sentiment.

2. The responses of the total GDP remain practically constant for all horizons, which means that qualitatively different responses of the total GDP over time were driven mainly by $pgdp_t$ responses. Furthermore, the total GDP responses reflect changes in the public sector components of the GDP only in the absence of meaningful responses of $pgdp_t$.

Putting it all together, we report substantial and important role of the sentiment channel in propagating fiscal policy shocks to private sector activity. And our simulation exercises demonstrate that changes in sentiment is the driving force of the time-varying effectiveness of fiscal policy.

Figure 1.8: Counterfactual Simulation Exercises with Alternative Identification Scheme



Note: We report the impulse-response function (IRF) estimates from 5-variate VAR models with $sent_t$ ordered last to a 1% government spending shock. Solid lines are hypothetical response functions with additional sentiment shocks that are designed to hold sentiment unchanged for all forecast horizons. Dashed lines are the impulse-response function point estimate from unconstrained models accompanied by its 90% confidence bands.

1.5 What Explains the Changes in Sentiment?

In this section, we provide statistical inferences about how market participants revise their economic prospects when they receive new information on fiscal actions. For this purpose, we investigate the time-varying relationship between GDP growth forecasts and government spending growth forecasts that are formulated by experts in the private sector, which helps explain the time-varying output effects of fiscal policy via the sentiment channel.

1.5.1 Understanding Dynamics of Sentiment through the Lens of the SPF

We first study how private agents revise their forecasts of real GDP growth when they update information on real government spending growth. For this purpose, we employ the Survey of Professional Forecasters (SPF) data for the period between $1968Q4$ and $2017Q3$. We are particularly interested in the relationship between the SPF forecasts of real GDP growth and those of real federal government spending growth.[22]

Let $\gamma_{x_t}^{SPF}(j+1) = x_{t+j}^{SPF} - x_{t-1}^{SPF}$ be the SPF growth rate forecast of (logged) x_t over $j+1$ quarters, while $\gamma_{x_t}(j+1) = x_{t+j} - x_{t-1}$ denotes the realized counterpart of $\gamma_{x_t}^{SPF}(j+1)$. We define the SPF forecast errors by $\hat{\gamma}_{x_t}(j+1) = \gamma_{x_t}^{SPF}(j+1) - \gamma_{x_t}(j+1)$. Note that we do not square forecast errors because the sign of the errors delivers important information. We first present the SPF forecast errors of real GDP growth over 5 quarters, $\hat{\gamma}_{y_t}(5)$, in Figure 1.9.[23] Some interesting observations are as follows.

Note that private forecasters tend to over-estimate the real GDP growth rate ($\hat{\gamma}_{y_t}(5) > 0$) during the pre-Volcker era ($1968Q4 - 1979Q2$), while they predominantly under-estimate it ($\hat{\gamma}_{y_t}(5) < 0$) during the post-Volcker era until the early 2000s. During the 2000s period, the SPF forecasts stay overall optimistic ($\hat{\gamma}_{y_t}(5) > 0$) till the beginning of the Great Recession, followed by much weaker optimistic forecasts.

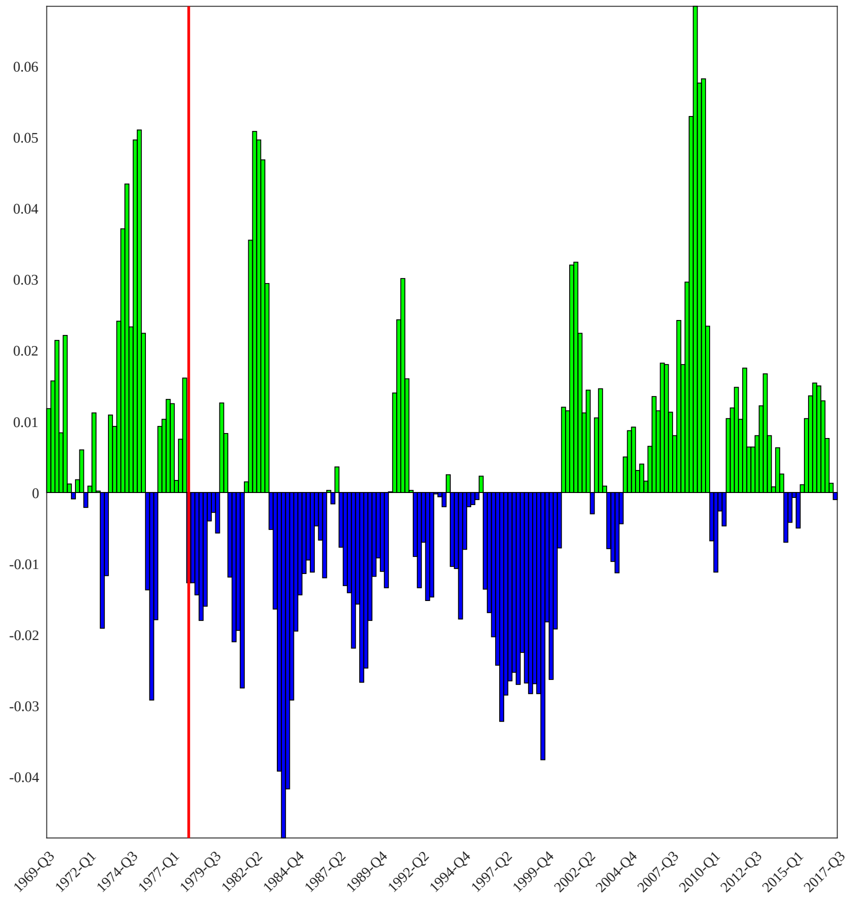
We conjecture that these systemic forecast errors are closely related with the structural break in the monetary policy stance suggested by Clarida et al. (2000), who pointed out that the Federal Reserve's interest rate setting behavior has changed when Paul Volcker took office in

[22] See the data description section for a detailed explanation on how these data are constructed.
[23] The vertical line is the break date, which is estimated by the structural break test presented in the next section.

the third quarter of 1979. To put it differently, they suggested that the monetary policy stance had stayed overall accommodative during the pre-Volcker era, while the stance of monetary policy had turned hawkish during the post-Volcker era.

This implies that private forecasters formulated more optimistic GDP growth forecasts when monetary policy coordinated well with fiscal policy during the pre-Volcker era. On the other hand, it seems that they have formulated more pessimistic GDP growth forecasts during the post-Volcker era when monetary policy stayed hawkish until the beginning of the 2000s. In the early 2000s, Greenspan has initiated an array of aggressive rate cuts to fight the recession triggered by the burst of the so-called dot com bubble in 2001. Such optimism in the early 2000s has become subdued rapidly when the Great Recession began in $2007-2008$.

Figure 1.9: SPF Forecast Errors for the Real GDP Growth Rate



Note: We report the 5-quarter ahead SPF forecast errors for the real GDP growth rate. The vertical line represents the break date estimate from SupF_T test.

We investigate this possibility by examining the time-varying relationship between $\gamma_{gt}^{SPF}(1)$ and $\gamma_{yt}^{SPF}(5)$ by the following least squares (LS) regression over time using a fixed-size rolling window scheme.

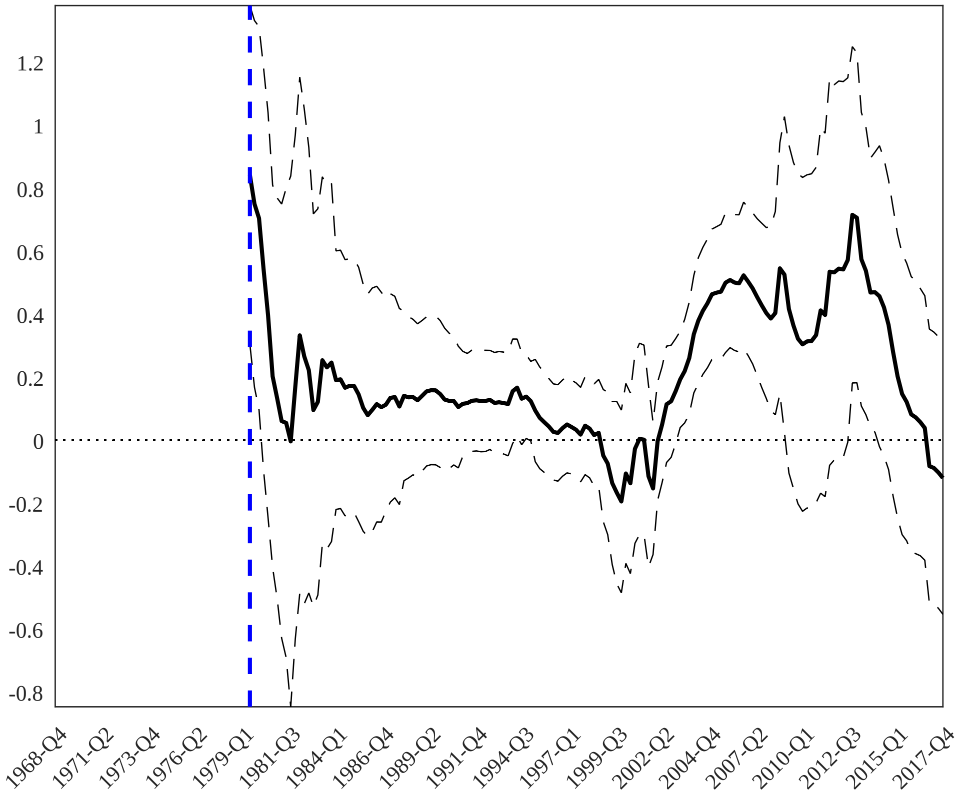
$$\gamma_{yt}^{SPF}(5) = \alpha + \beta\gamma_{gt}^{SPF}(1) + \varepsilon_t \tag{1.26}$$

The motivation of this regression analysis is the following. When market participants receive new information on government spending growth, $\gamma_{gt}^{SPF}(1)$, the realized (actual) patterns of revisions of their real GDP growth forecasts in the future, $\gamma_{yt}^{SPF}(5)$, would reveal their view about the effectiveness of the government spending shock. That is, β is likely to be greater when forecasters are optimistic on the effect of fiscal stimulus. As forecasters become less optimistic or even pessimistic, β will decrease to zero or even become negative.

Figure 1.10 presents the LS estimates $\hat{\beta}_{LS}$ for β in (1.26) over time with a 44-quarter fixed size rolling window so that the initial point estimate corresponds to β from the pre-Volcker era. We also report the 90% confidence bands that are obtained from the normal approximation. This initial $\hat{\beta}_{LS}$ is 0.843, which is significant at the 5% level. However, the $\hat{\beta}_{LS}$ estimate rapidly declines as the sample window starts including observations from the post-Volcker era. Note that confidence bands expand greatly since then, reflecting dramatic changes in $\hat{\beta}_{LS}$ after Mr. Volcker started extremely hawkish anti-inflation policies. This implies that market participants may formulate expectations of a lot weaker and statistically insignificant output effects of fiscal policy when the stance of monetary policy becomes hawkish.

The $\hat{\beta}_{LS}$ becomes stabilized eventually until it begins rising from the early 2000s, reflecting accommodative monetary policy actions implemented by Mr. Greenspan to fight the recession that began in 2001 followed by the burst of the so-called dot com (IT) bubble. Note that the $\hat{\beta}_{LS}$ point estimates remain overall high even during the Great Recession as the monetary policy becomes extremely accommodative with three rounds of quantitative easing (QE). However, the confidence bands become wider possibly reflecting high degree uncertainty and the fact that the role of monetary policy has become limited during the zero-lower-bound (ZLB) era. The $\hat{\beta}_{LS}$ starts falling around the mid 2010s when the Fed began the normalization plan of monetary policy. Putting all together, Figures 1.9 and 1.10 provide strong evidence of time-varying sentiment responses to the government spending shock through the lens of the SPF.

Figure 1.10: LS Estimates for β with a Fixed Size Rolling Window Scheme



Note: We report the LS estimates $\hat{\beta}_{LS}$ for β over time with a 44-quarter fixed size rolling window so that the initial point estimate corresponds to the pre-Volcker era ($1968Q4 \sim 1979Q3$). We obtained the 90% confidence bands (dashed lines) via the normal approximation.

1.5.2 Statistical Evidence of Structural Breaks

This subsection presents statistical evidence in favor of our conjectures presented in the previous section, which imply the presence of structural breaks in β. For this, we implement structural break tests for (1.26), employing the test procedure proposed by Hansen (1997, 2001).

Consider the following alternative hypothesis, $H_A : \beta_1 \neq \beta_2$, where $\beta = \beta_1,\ t \in [1, \tau]$ and $\beta = \beta_2,\ t \in (\tau, T]$, which implies a break at time $t = \tau$. We obtain the following three statistics proposed by Andrews (1993) and Andrews and Ploberger (1994) using the full sample

(T).[24]

$$
\begin{aligned}
\text{Sup}F_T &= \sup_{k_1 \le k \le k_2} F_T(k) \qquad (1.27)\\
\text{Exp}F_T &= \ln\left(\frac{1}{k_2 - k_1 + 1}\sum_{t=k_1}^{k_2} \exp\left(\frac{1}{2}F_T(k)\right)\right)\\
\text{Ave}F_T &= \frac{1}{k_2 - k_1 + 1}\sum_{t=k_1}^{k_2} F_T(k),
\end{aligned}
$$

where $F_T(k)$ denotes the Lagrange Multiplier statistics for the null hypothesis of no structural break, $H_0 : \beta_1 = \beta_2$, given a fine candidate grid point $k \in [k_1,\ k_2]$.[25] We used conventional trimming parameter values, $k_1 = 0.15T$ and $k_2 = 0.85T$. p values are obtained using the method by Hansen (1997).

As can be seen in Table 1.2, the three tests in (1.27) strongly support the presence of a structural break from the full sample, rejecting the null hypothesis of no structural break with virtually zero p values. The SupF_T test selects $1978Q2$ as the identified break date from the full sample, which roughly corresponds to the beginning of the post-Volcker era.

Following the sequential test approach by Hansen (2001), we seek additional break dates in the two subsample periods that are identified by the first structural break date, $1969Q4 - 1978Q2$ and $1978Q2 - 2017Q3$. We obtained no further evidence of a structural break in both the sub-sample periods even at the 10% significance level, concluding there was a single break in $1978Q2$.[26]

[24]The Chow test is not a feasible option because the structural break date is unknown.
[25]Alternatively, one can use the Wald or Likelihood Ratio test statistics.
[26]Test results for the earlier period are available upon request.

Table 1.2: Structural Break Tests for β

		Test stat.		
Sample Period	Break Date	SupF_T	ExpF_T	AveF_T
1968Q4~2017Q4	1978Q2	19.19	6.18	7.17
		(0.00)	(0.00)	(0.00)
1978Q2~2017Q4	N/A	5.64	1.56	2.60
		(0.46)	(0.29)	(0.24)

Note: The regression equation is motivated to understand how forecasters revise their economic forecasts when they update their information on government spending. We employed a sequential structural break test procedure proposed by Hansen (2001). $p-$values are reported in parentheses.

1.6 Concluding Remarks

The slow recovery from the recent Great Recession has revived the debate on the effectiveness of fiscal stimulus among the economics profession. Can increases in government spending help stimulate private activity? What variables play a dominant role in propagating government spending shocks to private spending? Empirical evidence is at best mixed, and the economics profession has failed to reach a consensus.

Motivated by the work of Leeper et al. (2017), we present New Keynesian macroeconomic models that yield strong output effects of fiscal stimulus only when monetary policy coordinates well with fiscal policy. When the central bank responds to inflation aggressively, private spending tends to fall in response to government spending shocks because the central bank raises the interest rate faster than inflation, resulting in an increase in the real interest rate.

Employing the post-war U.S. macroeconomic data, we confirm these predictions about the output effects of fiscal policy. During the pre-Volcker era, the private GDP rises as consumption increases rapidly in response to fiscal spending shocks. Such strong stimulus effects rapidly disappear when the sample period moves to the post-Volcker era. Although the empirical findings are overall consistent with theoretical predictions as to the output effects of fiscal policy, we observe a negligible role of the real interest rate in the propagation mechanism of fiscal stimulus to private spending, which is at odds with New Keynesian models.

The present paper proposes a sentiment channel as an alternative propagation mechanism. We demonstrate sentiment leads innovations in consumption rather than passively reflecting changes in consumption. Employing the Survey of Professional Forecasters data, we show forecasters tend to make systemic forecast errors. More specifically, they were likely to overestimate (optimism) real GDP growth when monetary and fiscal policies coordinate well with each other. When policies conflict with each other, however, they often formulated more pessimistic forecast. That is, they were prone to underestimate economic growth in the near future.

We further investigate how forecasters revise their economic prospects when they receive new information on fiscal actions. Our regression analyses demonstrate that positive innovations in government spending tend to trigger more optimistic GDP growth forecasts when monetary policy-makers maintain a dovish stance. When the central bank responds to inflation aggressively, however, forecasters are likely to formulate more pessimistic economic prospects. That is, fiscal stimulus under such circumstances generates consumer pessimism that decreases private spending, ultimately weakening the output effects of fiscal policy. We corroborate our analyses by further providing statistical test results that confirm an important role of the sentiment channel under different regimes of policy coordination.

Chapter 2

Can Fiscal Policy Improve Labor Market Conditions?

2.1 Introduction

Observing the slow economic recovery since the onset of the Great Recession, the economics profession got engaged in heated debates over the effectiveness of government policies in stimulating economic activities in the private sector. For example, the American Recovery and Reinvestment Act (ARRA), one of the largest fiscal stimulus programs in American history, was enacted by Congress and signed into law by President Obama in February 2009. One of the main objectives of the law is to preserve and creates jobs. However, it took a decade for the unemployment rate to return to its pre-crisis level.[1] Feyrer and Sacerdote (2011) reported somewhat weak and mixed job creation effects of the ARRA that implies Keynesian multipliers between 0.5 and 1.0. Crucini and Vu (2017) claimed that the ARRA was not successful in assisting those most in need.

New Keynesian models overall imply that fiscal stimulus are able to increase labor demand, generating an increase in employment, real wage, and output, although such effects often require heavily restricted models. See, among others, Rotemberg and Woodford (1992), Devereux et al. (1996), Galí et al. (2007) and Monacelli et al. (2010). On the other hand, neoclassical models find that government spending does not appear to effectively stimulate private activity. For instance, Ramey (2011a) points out that expansionary government spending shocks tend to decrease consumption and private employment due to a negative wealth effect. See, among others, Aiyagari et al. (1992), Linnemann and Schabert (2003), Burnside et al. (2004), Cavallo (2005) and Ardagna (2007).

[1] The unemployment rate went down below 5% in January 2016.

Besides, it should be noted that well coordinated policies are crucial in determining the path of fiscal policy. Sargent and Wallace (1984) were among the first who emphasized this by modelling the interaction between fiscal and monetary policies. Many other model-based analysis claim that shifts in monetary-fiscal policy regime greatly affects dynamics of policy impacts on key macroeconomic variables. See among others, Chung et al. (2007), Schmitt-Grohé and Uribe (2007), Zubairy (2014), Leeper et al. (2017), Kim and Zhang (2018), and Bianchi and Melosi (2018). Also, Hall (2009) and Christiano et al. (2011) suggest that the government spending multiplier can be greater when the nominal interest rate is bounded at zero.

Empirically, there exists little consensus on the sign of private sector responses to government spending shocks. On the one hand, Fatás and Mihov (2001), Blanchard and Perotti (2002), Pappa (2009), Linnemann (2009) and Perotti (2011) report that the response of private employment and output to government spending shocks are positive. Many others, on the other hand, are skeptical about the effectiveness of fiscal policy. For example, Ramey (2012) finds that increases in government spending may lower unemployment only through an increase in government employment, not private employment. See, among others, Malley and Moutos (1998), Algan et al. (2002) and Kim (2018). Besides, nonlinearity of fiscal policy has been discussed more often especially since the Great Recession. For example, Fazzari et al. (2015), Auerbach and Gorodnichenko (2012), Mittnik and Semmler (2012), and Bachmann and Sims (2012) claim that fiscal policy tends to have a stronger stimulating effect during times of slack, whereas Owyang et al. (2013), Kim and Jia (2017), and Ramey and Zubairy (2018) report no such evidence.

Many research works proposed that opposite effects of different types of fiscal shocks on private activity might be one possible reason why there are mixed evidence on the effects of government spending. For example, Wynne et al. (1992), Finn (1998), Edelberg et al. (1999) and Gomes (2010) find that increased government purchases of private goods lead to increased output and employment, while increased government employment may crowd out private activity. On the contrary, Bermperoglou et al. (2017) argue that government employment shocks are expansionary by increasing labor force participation and private employment. In addition, Afonso and Gomes (2014) find that the growth of public sector wages and employment positively affects the growth of private sector wages, whereas Stähler and Thomas (2012) state that government wages shocks can be contractionary.

Given the weight of compensation of government employees in federal government spending, this paper investigates how labor market variables respond to an exogenous increase in government employment. Leeper et al. (2017) propose that the monetary-fiscal mix overshadows the many other factors on which existing research dwells. Motivated by their work, we evaluate the fiscal policy impacts under different fiscal and monetary policy regimes. Specifically, we consider alternative monetary policy regimes given the expansionary fiscal policy: either a dovish monetary policy coordinated well with expansionary fiscal policy (Regime D) or a hawkish monetary policy conflicted with fiscal stimulus (Regime H).[2]

Our simulation results imply that fiscal stimulus improves the labor market conditions only when fiscal and monetary policies are well coordinated. Moreover, the real interest rate plays a key role in propagating government employment shocks into private sector economic activity. We acknowledge that Leeper et al. (2017) also demonstrate the state-dependent stimulus effects of fiscal policy under different fiscal-monetary policy regimes. However, their major findings are based on counterfactual analyses, whereas our results are supported by historical evidence of the time-varying effects of fiscal stimulus as described below.

We empirically assess the validity of these predictions via a recursively identified vector autoregressive (VAR) model for the post-war U.S. macroeconomic data. We distinguish employment and wages in the private sector from those in the government sector. Our empirical findings confirm the predictions of our DSGE model that fiscal policy has become less effective in improving labor market conditions over time. Specifically, government employment shocks increase private employment, employment-population rate, private wage, and lower unemployment rate during earlier sample periods when the Fed stayed accommodative. On the other hand, the government employment shock create negative labor market effects when the central bank switches to a hawkish stance that conflicts with the expansionary fiscal policy. That

[2] We observe the federal government deficit in 75 out of 89 years from 1929 to 2017, which is about 84% odds (FYFSGDA188S; FRED).

is, we observe that private employment and private wages fall in response to the government employment shock, while unemployment rate increases.

Our empirical findings are consistent with the overall predictions of our DSGE model with the exception of the role of the real interest rate. That is,our estimation results reveal a negligible role of the real interest rate in propagating fiscal stimulus to the labor market, which contrasts with the prediction of our theoretical model. To resolve this issue, we propose a sentiment channel as an alternative propagation mechanism to the interest rate channel under different policy-mix regimes. See, among others, Hall (1993), Blanchard (1993), Cochrane (1994), Beaudry and Portier (2006, 2007), Bachmann and Sims (2012), Kim and Jia (2017), and Kim and Zhang (2018).

We supplement our view by utilizing the Survey of Professional Forecasters (SPF) data by extracting useful information on how market participants revise their prospects for unemployment rate when the government implements new policy actions. Our analysis demonstrates that forecasters tend to persistently under-predict unemployment changes (optimism) when monetary policy is well coordinated with fiscal policy, while systemic over-predictions (pessimism) are observed when the Fed is in a hawkish stance. The structural break in the sign of the forecast errors can be viewed as changes in sentiment.

Further, we regress five-quarter ahead forecasts of unemployment rate change on one-quarter ahead forecasts of real government spending growth, employing a fixed-size rolling window scheme. The point estimate displays strong negative correlations (optimism) during the pre-Volcker era, while positive correlations (pessimism) were observed when the Fed began to conduct hawkish monetary policy. This further strengthens the evidence that time-varying responses in sentiment is the driving force of the time-varying effects of fiscal policy on the labor market. In a nutshell, we conclude that fiscal stimulus tends to generate consumer pessimism when policies conflict with each other, depressing the aggregate demand, which ultimately crowds out private labor market.

The outline of the paper is as follows. Section 2 presents our baseline New Keynesian models. Section 3 reports simulation results. Section 4 introduces our VAR models with data descriptions and our major empirical findings. We also present a sentiment channel that help understand the time-varying responses of labor market variables to the fiscal shock. Section 5 provides a novel statistical approach using the SPF data to document the important role of the sentiment channel. Section 6 concludes.

2.2 The Theoretical Model

We present a New Keynesian model that features external habit formation in consumption, variable capacity utilization, investment adjustment costs, and monopolistic competition in the production. Sticky prices and sticky wages are modeled using the framework of Calvo (1983) and Yun (1996). Government output directly enters household's utility as a complement to private consumption, because this specification in a sticky-price model turns out to help reconcile theory and empirical evidence. For more details, see among others, Linnemann and Schabert (2004) and Leeper et al. (2017). One important extended detail in our model is that we distinguish production in private goods and public goods. Monetary authority follows a Taylor rule, while fiscal rules are specified with feedback to government debt as described in Leeper et al. (2017). In what follows, we demonstrate the effectiveness of fiscal stimulus on the labor market critically hinges upon the stance of monetary policy.[3]

2.2.1 Households

There is a continuum of households on the interval $[0, 1]$. Each household i derives utility from composite consumption ($c^*_{i,t}$) consisting of private goods ($c_{i,t}$) and public goods (y^g_t), $c^*_{i,t} \equiv c_{i,t} + \alpha_g y^g_t$ where parameter α_g governs the degree of substitutability of the consumption goods. When $\alpha_g < 0$, private and public consumption are complements (Leeper et al. (2017)), whereas $\alpha_g > 0$ implies that these are substitutes with each other (Christiano and Eichenbaum (1992); Ambler and Paquet (1996); Finn (1998)). Each household i supplies a continuum of differentiated labor indexed by l, $n_{i,l,t}, l \in [0, 1]$. The aggregate labor supply is $n_{i,t} \equiv \int_0^1 n_{i,l,t} dl$ where $n_{i,t} \equiv n^p_{i,t} + n^g_{i,t}$ consists of workers hired by firms $n^p_{i,t}$ and government employees $n^g_{i,t}$.

[3] We assume stronger degree feedback of government spending to government debt when the stance of monetary policy is more aggressive to inflationary pressure.

Households maximize the following lifetime utility

$$E_t \sum_{t=0}^{\infty} \beta^t \left(\ln \tilde{c}_{i,t} - \chi \frac{n_{i,t}^{1+\eta}}{1+\eta} \right) \tag{2.1}$$

where $\beta \in (0,1)$ is the discount factor. $\tilde{c}_{i,t} = c^*_{i,t} - hc^*_{a,t-1}$ where $h \in (0,1)$ governs the degree of external habit formation and the habit stock is given by a fraction of aggregate consumption from the previous period $hc^*_{a,t-1}$. The household's real flow budget constraint is given by:

$$c_{i,t}+i_{i,t}+\frac{R_t B_{i,t}}{P_t} \leq \frac{B_{i,t-1}}{P_t}+(1-\tau^n)\int_0^1 \frac{W_{l,t}}{P_t} n_{i,l,t} dl+\left[\left(1-\tau^k\right)\frac{R_t^k}{P_t}\mu_{i,t} - a\left(\mu_{i,t}\right)\right] k_{i,t-1}+\frac{D_{i,t}}{P_t}+tr \tag{2.2}$$

where the left-hand side represents the uses of income, given by private consumption ($c_{i,t}$), investment ($i_{i,t}$), and purchases of nominal government debt ($B_{i,t}$) deflated by P_t. The right-hand side denotes the sources of income consisting of interest payments of government debt, after-tax nominal wage (W_t) and capital rental (R_t^k) income, dividends distributed by the intermediate goods firms ($D_{i,t}$) and constant lump-sum transfer payments from the government (tr). τ^n and τ^k are constant tax rates levied on labor income and capital, respectively.[4]

The effective amount of capital services is represented by $u_{i,t}k_{i,t-1} \equiv k^s_{i,t}$, whereas $a(u_{i,t})k_{i,t-1}$ describes the physical cost associated with variations in the degree of capacity utilization, which is parameterized by a quadratic function $a\left(u_{i,t}\right) = \zeta_1\left(u_{i,t}-1\right) + \frac{\zeta_2}{2}\left(u_{i,t}-1\right)^2$. [5] Note that $u = 1$ and $a(1) = 0$ in the steady state. We also define $\frac{a''(1)}{a'(1)} \equiv \frac{\zeta_2}{1-\zeta_2}$ following Smets and Wouters (2007).[6]

The law of motion for capital is:

$$k_{i,t} = (1-\delta)\, k_{i,t-1} + \left[1 - S\left(\frac{i_{i,t}}{i_{i,t-1}}\right)\right] i_{i,t} \tag{2.3}$$

where δ is the depreciation rate and $S\left(\cdot\right)$ denotes an adjustment cost function, proposed by Christiano et al. (2005), such that $S\left(1\right) = S'\left(1\right) = 0$, and $\kappa \equiv S''\left(1\right) > 0$.

[4] We assume constant tax rates to focus mainly on the transmission channel of government spending given the tax policy.

[5] Note that we use the *end of period stock* timing convention. For example, k_{t-1} is the capital stock that was determined by investment at time $t-1$, but is used at time t in the production function for y_t.

[6] We need this condition to linearize the model presented here.

2.2.2 Firms

The final private good (y_t^p) is a composite good of a continuum of intermediate goods (y_{jt}^p), characterized by a Dixit and Stiglitz (1977) aggregator: $y_t^p = \left[\int_0^1 \left(y_{jt}^p\right)^{(\theta_p-1)/\theta_p} dj\right]^{\theta_p/(\theta_p-1)}$, where $\theta_p > 1$ governs the degree of substitution between the inputs. Taken input prices (P_{jt}) and output prices (P_t) as given, the profit maximization yields the demand for intermediate good i as $y_{jt} = (P_{jt}/P_t)^{-\theta_p} y_t$, where $P_t = \left(\int_0^1 P_{jt}^{1-\theta_p} dj\right)^{1/1-\theta_p}$. The intermediate good j is produced by a monopolistically competitive firm who has access to the production function:

$$y_{j,t}^p = \left(n_{j,t}^p\right)^{1-\alpha} \left(k_{j,t}^s\right)^{\alpha} \tag{2.4}$$

where $\alpha \in (0,1)$. $n_{j,t}^p$ and $k_{j,t}^s \equiv \mu_{j,t} k_{j,t-1}$ denote the level of labor and capital services used by firm j, respectively.

Each monopolistically competitive firm solves a two-stage problem. In the first stage, taken input prices (W_t) and (R_t^k) as given, each firm rents labor (n_{jt}) and capital (k_{jt}^s) to minimize its operating cost, $W_t n_{jt} + R_t^k k_{jt}^s$, subject to its production function. Cost minimization yields the identical marginal cost:

$$\frac{W_t}{R_t^k} = \frac{1-\alpha}{\alpha} \frac{k_{j,t}^s}{n_{j,t}^p} \tag{2.5}$$

$$MC_t = \sigma W_t^{1-\alpha} \left(R_t^k\right)^{\alpha} \tag{2.6}$$

where $\sigma = \alpha^{-\alpha} (1-\alpha)^{\alpha-1}$. In the second stage, each intermediate goods firm chooses its price (P_{jt}) to maximize the discounted present value of future profits subject to the demand for y_{jt}.

Following the price-setting scheme proposed by Calvo (1983), each intermediate firm faces a fixed probability, $(1-\omega_p)$, of being able to reoptimize its price, P_t^*, in any given period. With probability ω_p, it partially indexes its price to past inflation according to the following rule:

$$P_{t+k|t} = \pi_{t+k-1}^{\iota_p} \pi^{1-\iota_p} P_{t+k-1|t}, k = 1, 2, 3, ... \tag{2.7}$$

where $\pi_t \equiv \frac{P_t}{P_{t-1}}$ is the gross inflation rate between $t-1$ and t and $\bar{\pi}$ is the steady state inflation. $P_{t+k|t}$ denotes price in period $t+k$ of a firm that last reoptimized its price in period t and $P_{t|t} = P_t^*$. Indexation is controlled by the parameter $\iota_p \in [0,1]$ allowing for any degree of combination of the two types of indexation usually employed in the literature, steady state inflation (e.g., Yun (1996)) and the past inflation rate (e.g., Christiano et al. (2005)). Throughout this paper, variables with a bar denote steady state values.

The profit maximization problem for firms that reoptimize their prices at time t is:

$$\max_{P_t^*} E_t \sum_{k=0}^{\infty} \omega_p^k \left\{ \beta^k \frac{\lambda_{t+k} P_t}{\lambda_t P_{t+k}} \left[\left(P_{t+k|t} - MC_{t+k} \right) y_{t+k|t}^p \right] \right\} \tag{2.8}$$

$$s.t. \quad y_{t+k|t}^p = \left(\frac{P_{t+k|t}}{P_{t+k}} \right)^{-\theta_p} y_{t+k}^p, \quad P_{t+k|t} = \left(\prod_{s=1}^{k} \pi_{t+s-1}^{\iota_p} \bar{\pi}^{1-\iota_p} \right) P_t^*$$

where the nominal profit at date $t+k$ is discounted by the pricing kernel $\beta^k \left(\lambda_{t+k}/\lambda_t\right) \left(P_t/P_{t+k}\right)$ and λ_t is the marginal utility (or shadow price) of wealth of households at time t, which is treated as exogenous by firms. The optimality condition from (2.8) implies

$$E_t \sum_{k=0}^{\infty} \left(\omega_p \beta\right)^k \frac{\lambda_{t+k} P_t}{\lambda_t P_{t+k}} \left(P_{t+k|t} - \mathcal{M}^p MC_{t+k} \right) y_{t+k|t}^p = 0 \tag{2.9}$$

where $\mathcal{M}^p \equiv \frac{\theta_p}{\theta_p - 1}$. The aggregate price index evolves as follows:

$$1 = \left(1 - \omega_p\right) \left(\pi_t^*\right)^{1-\theta_p} + \omega_p \left(\frac{\pi_{t-1}^{\iota_p} \bar{\pi}^{1-\iota_p}}{\pi_t} \right)^{1-\theta_p} \tag{2.10}$$

where $\pi_t^* = \frac{P_t^*}{P_t}$.

2.2.3 Labor Market

There is a representative, competitive labor agency that hires a continuum of differentiated labor from each household and combines them into a homogeneous labor that is sold to intermediate firms with the following aggregator: $n_t = \left(\int_0^1 n_{l,t}^{\frac{\theta_w - 1}{\theta_w}} dl \right)^{\frac{\theta_w}{\theta_w - 1}}$, where $0 \leq \theta_w < \infty$ is the elasticity of substitution among different types of labor. This competitive labor agency maximizes its profit subject to the above production function, taking all differentiated labor wages ($W_{l,t}$) and the aggregate wage (W_t) as given, yielding:

$$n_{l,t} = \left(\frac{W_{l,t}}{W_t}\right)^{-\theta_w} n_t \tag{2.11}$$

where W_t is the aggregate nominal wage that satisfies $W_t \equiv \left(\int_0^1 W_{l,t}^{1-\theta_w} dl\right)^{\frac{1}{1-\theta_w}}$.

Following Erceg et al. (2000), wage stickiness is introduced in a way that is analogous to price stickiness described above. In each period, a fraction $1-\omega_w$ of households can adjust their wages to W_t^* and others can only index their wages by past inflation. Let $W_{t+k|t}$ be the nominal wage in period $t+k$ for workers who last reoptimized their wage in period t, those workers can only index their wages to past inflation as follows:

$$W_{t+k|t} = \pi_{t+k-1}^{\iota_w} \pi^{1-\iota_w} W_{t+k-1|t}, k = 1, 2, 3, ... \tag{2.12}$$

where indexation is controlled by the parameter $\iota_w \in [0,1]$ and $W_{t|t} = W_t^*$. Therefore, the wage-setting problem of households who reset their wages at time t can be written as:

$$\max_{W_t^*} E_t \sum_{k=0}^{\infty} (\omega_w \beta)^k U\left(c_{t+k}, n_{t+k|t}\right)$$
$$s.t. \quad n_{t+k|t} = \left(\frac{W_{t+k|t}}{W_{t+k}}\right)^{-\theta_w} n_{t+k}, \quad W_{t+k|t} = \left(\prod_{s=1}^{k} \pi_{t+s-1}^{\iota_w} \pi^{1-\iota_w}\right) W_t^*$$

where $n_{t+k|t}$ denotes period $t+k$ employment among workers whose wage was last reoptimized in period t. The first order condition associated with the wage-setting problem can be written as:

$$\sum_{k=0}^{\infty} (\omega_w \beta)^k E_t \left[\frac{n_{t+k|t}}{\tilde{c}_{t+k}} \left(\frac{W_{t+k|t}^*}{P_{t+k}} - \mathcal{M}^w MRS_{t+k|t}\right)\right] = 0 \tag{2.13}$$

where $\mathcal{M}^w \equiv \frac{\theta_w}{\theta_w - 1}$, $\tilde{c}_{t+k} \equiv c_{t+k}^* - hc_{t+k-1}^*$,and $MRS_{t+k|t} \equiv \varrho \tilde{c}_{t+k} n_{t+k|t}^{\eta}$ is the relevant marginal rate of substitution between consumption and employment in period $t+k$. Therefore, the aggregate wage index is described as follows:

$$1 = (1-\omega_w)\left(\pi_{w,t}^*\right)^{1-\theta_w} + \omega_w \left(\frac{\pi_{t-1}^{\iota_w} \pi^{1-\iota_w}}{\pi_t} \frac{W_{t-1}}{W_t}\right)^{1-\theta_w} \tag{2.14}$$

where $\pi^*_{w,t} = \frac{Wt^*}{W_t}$.

2.2.4 Monetary and Fiscal Authorities

The monetary policy follows a Taylor rule. It adjusts the gross nominal interest rate (R_t) in response to the deviations of inflation (π_t) and output (y_t) from their respective steady state levels:

$$R_t = R_{t-1}^{\psi_r}\left[\bar{R}\left(\frac{\pi_t}{\bar{\pi}}\right)^{\phi_\pi}\left(\frac{y_t}{\bar{y}}\right)^{\phi_y}\right]^{1-\psi_r} \tag{2.15}$$

where $0 \leq \psi_r < 1$ is the interest rate smoothing parameter, $\bar{R}$ is the equilibrium real interest rate, ϕ_π and ϕ_y are the policy response parameters to the inflation gap and the output gap, respectively.

The government purchases goods from private sector, (g_t), to produce public goods, (y_t^g) using the following production function

$$y_t^g = \left(n_t^g\right)^\gamma g_t^{1-\gamma} \tag{2.16}$$

where n_t^g denotes public labor and $\gamma \in (0,1)$. We assume that for households, the wage paid by the government is equal to the wage paid by private firms. In each period, government's income consists of tax revenues, proceeds from sales of one-period debt and the public good to finance its expenditures that include repayment of debt, government private goods purchases (g_t), salaries and wages ($\frac{W_t}{P_t}n_t^g$) and transfer payments (tr). The government's flow budget constraint (GBC) is

$$\frac{R_{t-1}B_{t-1}}{P_t} + \frac{W_t}{P_t}n_t^g + g_t + tr = \frac{B_t}{P_t} + \tau^n\frac{W_t}{P_t}n_t + \tau^k\frac{R_t^k}{P_t}\mu_t k_{t-1} + y_t^g \tag{2.17}$$

Fiscal rules for g_t and n_t^g obey the following stochastic processes:

$$g_t = g_{t-1}^{\psi_g}\left[\bar{g}\left(b_{t-1}/\bar{b}\right)^{-\gamma_g}\right]^{1-\psi_g} \tag{2.18}$$

$$n_t^g = \left(n_{t-1}^g\right)^{\psi_{ng}}\left[\bar{n^g}\left(b_{t-1}/\bar{b}\right)^{-\gamma_{ng}}\right]^{1-\psi_{ng}}\nu_{n^g,t} \tag{2.19}$$

where the parameter $\psi_{n^g} \in (-1, 1)$ governs the degree of the persistence of n_t^g. In order to ensure determinacy of equilibrium and a nonexplosive solution for debt, we allow n_t^g to respond to deviations of the (lagged) real debt $b_{t-1} = \frac{B_{t-1}}{P_{t-1}}$ from its stead state value $\bar{b}$ following Leeper et al. (2017). That is, the parameter $\gamma_{n^g} > 0$ triggers a correction of government spending when real debt deviates from its stead state value. $\nu_{n^g,t}$ is government employment shock which is assumed to follow stationary ($\rho_{n^g} < 1$) AR(1) processes:

$$\ln \nu_{n^g,t} = \rho_{n^g} \ln \nu_{n^g,t-1} + \sigma_{n^g} \varepsilon_{n^g,t}, \varepsilon_{n^g,t} \sim \mathbb{N}(0, 1) \tag{2.20}$$

2.2.5 Market Clearing and Aggregation

We consider a symmetric equilibrium in which all intermediate good firms make identical choices so that the i subscript can be omitted. All goods and asset markets clear in the equilibrium. Specifically, the goods market clear condition requires the aggregate resource constraint,

$$y_t^p = c_t + i_t + a(\mu_t) k_{t-1} + g_t \tag{2.21}$$

$$y_t = y_t^p + y_t^g \tag{2.22}$$

where the private final good firm sells the final product to the households and the government. Government purchases are used for government output. y_t denotes total output, which is the sum of private output (y_t^p) and government output (y_t^g). Equilibrium conditions and their log-linearizations around the deterministic steady states are given in the Appendix. The log-linearized model is solved using the Sims (2002) gensys algorithm.

2.3 Model Simulations

2.3.1 Calibration

The model in section 2.2 is calibrated at a quarterly frequency. The baseline calibration is shown in Table 2.1. The discount factor (β) is set to 0.9958, which equals $(1/T) \sum_{t=1}^{T} \pi_t / (1 + (FFR_t/100))^{1/4}$ where T is the sample size from the data, π_t denotes the quarterly gross inflation rate, and FFR_t is the effective federal funds rate. The inverse Frisch labor supply elasticity ($1/\eta$) is set at 2. The quarterly depreciation rate for capital (δ) is set to 0.025, which implies an annual depreciation rate of 10%. The leisure preference parameter (χ) implies a steady state share of time spent working of 0.33. [7]

The response of private consumption to the fiscal shock is important when quantifying the effects on aggregate demand. We consider a model that embeds deep habit formation (h) and complementarities (α_g) in public and private consumption. Therefore, the habit formation coefficient and the complementarity parameter are set to 0.99 and -0.2, respectively (Leeper et al. (2017)). The capital share (α) in the private production function is set to 0.33 and the cost share of public employment in the public production function is set to 0.35 which is equal to the mean of the ratio of government employment compensation to government output during the sample period. The price elasticity of demand for individual good (θ_p) and the elasticity of substitution among different types of labor (θ_w) are all set to be 8. The capital utilization rate (ζ_2) and the adjustment cost for investment (κ) are set to 0.15 and 5, respectively. Price stickiness (ω_p) and wage stickiness (ω_w) are both set to be 0.8, implying a slightly over one-year average duration of price/labor contracts.

Monetary and fiscal parameters are based on the mean values from U.S. data over the period $1960Q1 - 2017Q3$. The steady state gross quarterly inflation rate ($\bar{\pi}$) is set to be 1.0082. The public-to-total employment ratio (n_g/n) is set to 0.17. The government purchase-to-government output ratio (g/y^g) is 0.65. The government debt-to-GDP ratio (s_b) is 1.3707. The persistence parameter (ρ_g) of government spending is assumed to be 0.98. The average labor tax rate (τ^n) is set to 0.2171 and the capital tax rate (τ^k) is 0.2497.

We set regime specific monetary policy parameters based on Taylor rule estimates for the pre-and post-Volcker era reported by Clarida et al. (2000). Government employment shocks are robustly expansionary in both regimes. We therefore define two distinct fiscal-monetary policy regimes as follows: in regime D, both monetary and fiscal policy are accommodative. To keep the balance between output and inflation, the dovish central bank responds only weakly to inflation so that the (long run) coefficients on inflation (ϕ_π) and on the output (ϕ_y) are set to

[7] This roughly matches the observation that individuals spend $1/3$ of their time engaged in market activities and $2/3$ of their time in non-market activities (Hansen (1985)).

0.83 and 0.27, respectively and the interest rate smoothing parameter (ψ_r) is set to be 0.68. This is consistent with policy stance during the pre-Volker era that ends right before Paul Volcker's appointment as the Federal Reserve chairman in $1979Q3$. γ_j for $j = g, n^g$ is set to 0 implying that fiscal instruments do not respond to government debt.

In regime H, however, the hawkish central bank raises the interest rate aggressively to curb inflationary pressure, which works in the opposite direction to the expansionary fiscal policy. ϕ_π, ϕ_y, and ψ_r are set to 2.15, 0.93, and 0.79, respectively. In this case, fiscal instruments adjust weakly to government debt with $\gamma_j = 0.07$ for $j = g, n^g$.

2.3.2 Simulation Results

Figure 2.1 displays simulated impulse-response functions (IRFs) of output and employment to 1% exogenous increase in government employment in both regimes. We observe striking differences in the effects of fiscal shocks across regimes. All output and employment rise strongly and persistently in regime D, where real interest rate decreases sharply as the monetary authority maintains a dovish monetary policy stance.

In contrast, private employment, total output and private output are consistently crowed out by government employment in regime H, where the central bank conducts a hawkish monetary policy to kill inflation, which is conflicted with the expansionary fiscal policy. As a result, real interest rate rises after slightly short decrease, which implies a negative effect on aggregate demand, resulting in decline in private output and private employment. Positive total employment is purely due to increase in government employment.

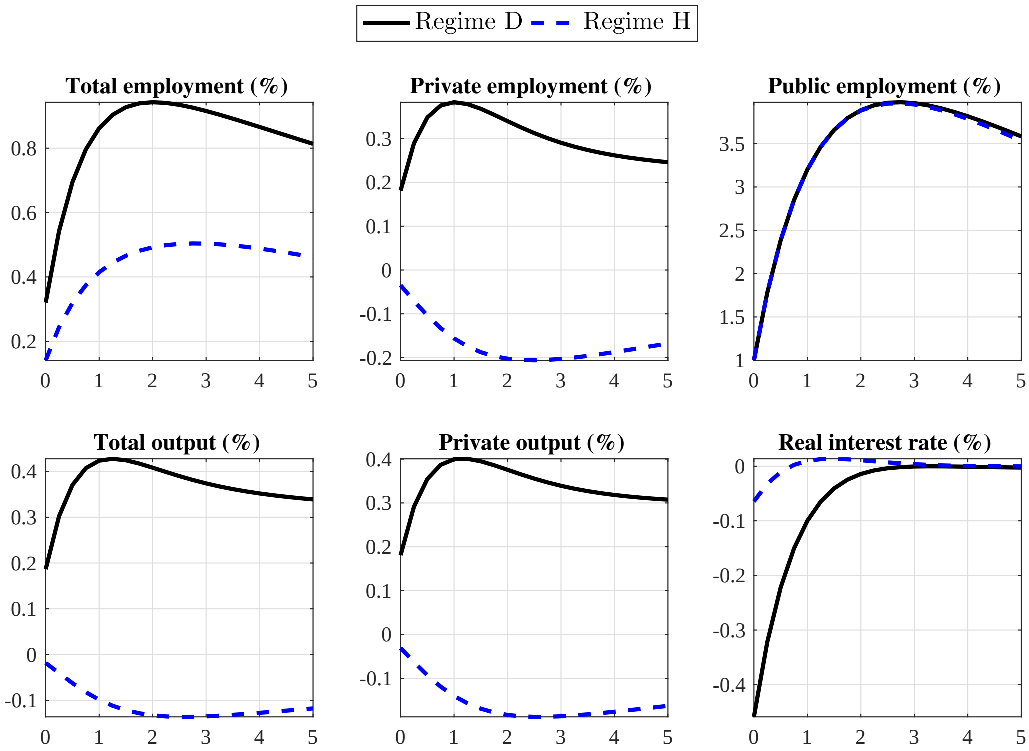
Therefore, the theoretical model makes clear that the relationship between monetary and fiscal policy determines the transmission of government employment shock. The fiscal policy stimulates the labor market only when fiscal and monetary policies are well coordinated. We next examine whether empirical evidence supports theoretical predictions.

Table 2.1: Parameter Calibrations

Preference and HHs	
β, discount factor	0.9958
h, habit formation	0.99
η, inverse Frisch labor elas.	2
$\bar{n}$, steady-state labor	1/3
δ, depreciation rate	0.025
α_g, subs. of private/public cons.	-0.2
Frictions and Production	
α, capital share	0.33
γ, public labor share	0.35
θ_p, elas. of subs. b/w intermediate goods	8
θ_w, elas. of subs. b/w different types of labor	8
ω_p, Calvo price stickiness	0.8
ω_w, Calvo wage stickiness	0.8
ζ_2, capital utilization	0.15
κ, investment adj. cost	5
Monetary/Fiscal Calibrations	
n_g/n, Public-total employment ratio	0.17
ψ_g, lagged resp. for govt spending	0.98
s_g, steady-state govt spending-to-GDP ratio	0.0945
s_b, steady-state debt-to-GDP ratio	1.3707
$\bar{\tau}^n$, steady-state labor tax rate	0.2171
$\bar{\tau}^k$, steady-state capital tax rate	0.2497
Regime D	
Monetary Policy	
ϕ_π, interest rate resp. to inflation	0.83
ϕ_y, interest rate resp. to output	0.27
ψ_r, resp. to lagged interest rate	0.68
Fiscal Policy	
γ_{n^g}, govt employment resp. to debt	0
Regime H	
Monetary Policy	
ϕ_π, interest rate resp. to inflation	2.15
ϕ_y, interest rate resp. to output	0.93
ψ_r, resp. to lagged interest rate	0.79
Fiscal Policy	
γ_{n^g}, govt employment resp. to debt	0.07
Shocks	
ρ_{n^g}, govt employment persistence	0.8
σ_{n^g}, govt employment	0.01

Note: Parameters are calibrated at a quarterly frequency.

Figure 2.1: Simulated Impulse Responses to the Government Employment Shock



Note: We report simulated responses over 5 years to a 1% government employment shock in each regime. The monetary authority is assumed to maintain an accommodative stance that coordinates well with expansionary fiscal policy under the Regime D. On the other hand, the central bank maintains a hawkish policy stance that conflicts the dovish stance of the government under the Regime H.

2.4 The Empirics

In this section, we formalize the econometric framework in order to estimate the effects of government employment on the labor market for the U.S. post-war macroeconomic data. Empirical evidence strongly supports time-varying responses of labor market variables to the fiscal shock. However, real interest rate plays a weak role in the propagation mechanism of fiscal policy, which is at odds with the simulation results presented above. We propose a sentiment channel as an alternative to the real interest rate channel.

2.4.1 Econometric Framework

Our basic vector autoregressive (VAR) specification is

$$\mathbf{x}_t = \gamma' \mathbf{d}_t + \sum_{j=1}^{p} \mathbf{A}_j \mathbf{x}_{t-j} + \mathbf{C}\varepsilon_t, \tag{2.23}$$

where

$$\mathbf{x}_t = [g_t \;\; y_t \;\; lab_t \;\; \mathbf{z}_t]$$

$\mathbf{d}_t$ is a vector of deterministic terms that includes an intercept and time trend. $\mathbf{C}$ is the lower-triangular Choleski factor and ε_t is a vector of orthonormal structural shocks, $E\varepsilon_t\varepsilon_t^{'} = \mathbf{I}$. We are particularly interested in the j-period ahead orthogonalized impulse-response function (IRF) defined as follows.

$$IRF_{k,j} = E\left(\mathbf{x}_{t+j}|\varepsilon_{k,t} = 1, \Omega_{t-1}\right) - E\left(\mathbf{x}_{t+j}|\Omega_{t-1}\right), \tag{2.24}$$

where $\varepsilon_{k,t}$ is the structural shock to the k^{th} variable in (2.23) that occurs at time t. Ω_{t-1} is the adaptive information set at time $t-1$, that is, $\Omega_j \supseteq \Omega_{j-1}, \forall j$.

The basic VAR contains the following variables: g_t is federal government employment, which is used to identify the fiscal shock. y_t is gross domestic product (GDP). lab_t is a scalar labor market variable employing one of the following five labor market variables: total employment ($tjob_t$), private employment ($pjob_t$), unemployment rate ($urat_t$), employment-population ratio ($erat_t$) and private sector wage (pw_t). $\mathbf{z}_t$ is a vector of control variables from the money market that includes the effective federal funds rate (int_t) and the log monetary base (mon_t). All variables are demeaned and detrended, up to quadratic trend, prior to estimations.

Following Blanchard and Perotti (2002), g_t is ordered first in $\mathbf{x}_t$, meaning that within a quarter there is no discretionary response of g_t to innovations in other variables. This identifying assumption is consistent with the observed evidence that it takes more than a quarter for fiscal policy to be changed in response to shocks. [8] Variables in $\mathbf{z}_t$ are ordered last as monetary policy can be revised regularly through the Federal Open Market Committee (FOMC) meetings. Since the Fed targets the interest rate, int_t is ordered before mon_t implying that the monetary base changes endogenously. Our empirical findings presented in this paper are robust to alternative VAR ordering. That is, all the IRFs to g_t are *numerically identical* even when all variables next to g_t are randomly re-shuffled. Christiano et al. (1999) proposes that IRFs are invariant given the location of the shocking variable.[9]

2.4.2 Data Description

We obtained all employment data from Labor Productivity and Costs Table of the Bureau of Labor Statistics and others from the Federal Reserve Economic Data (FRED) website. Observations are quarterly frequency and span from $1960Q1$ to $2017Q3$.

g_t is federal government jobs, which constitutes federal general government total employees plus armed forces personnel. GDP (gdp_t) is the gross domestic product (NGDP). Throughout the paper, all income/spending variables are log-transformed and are expressed in real per capita terms using GDP deflator (GDPDEF) and the civilian noninstitutional population (CNP16OV). The nominal interest rate (int_t) is the effective federal funds rate (FEDFUNDS) divided by 100, which can be used to identify the monetary policy shock.[10] mon_t is the monetary base (BOGMBASE), expressed in natural logarithm.

[8] Kim and Jia (2017) employed the government total expenditures that includes transfer payments in addition to the discretionary government consumption and investment spending. Since transfer payments have automatic stabilizers, they put g_t next to y_t.

[9] Similarly, all response functions to monetary policy shocks are robust to alternative ordering given the location of monetary variables, i_t and m_t.

[10] We observed no evidence of structural breaks in the output effects of monetary policy. Results are available upon requests.

We construct labor market variables as follows: private employment ($pjob_t$) is nonprofit institutions employees plus private nonfarm sector employees. Total employment ($tjob_t$) is defined as all workers, which exclude private households employees, farm employees, unpaid family workers and proprietors. Both employment variables are expressed in natural logarithm. We also consider two important labor market statistics: unemployment rate ($urat_t$; UNRATE) and employment-population rate ($erat_t$; EMRATIO). The private wage (pw_t) is wages and salaries of employees in private industries (A132RC1Q027SBEA) divided by the GDP deflator and $pjob_t$.

To investigate the propagation mechanism of fiscal policy through the sentiment channel, we augment the baseline VAR model (2.23) with the (log) Index of Consumer Expectations ($sent_t$), which reflects how consumers view prospects for the general economy over the near and long term. The data is obtained from the University of Michigan's Survey of Consumers database. We also tested with the Current Conditions Index and the Index of Consumer Sentiment (combined index) obtained from the same database. All three indices yield qualitatively similar empirical results.[11]

The median Survey of Professional Forecasters (SPF) data for relevant variables were obtained from the Philadelphia Fed, starting from $1968Q4$.[12] It should be noted that there were 9 changes in the base year in the National Income and Product Account (NIPA) during this sample period. Failing to adjust for changes in the based year results in 9 outlier observations in the data, see in Ramey (2011a) and Forni and Gambetti (2016). We re-scaled all relevant forecast data using 2009 as the common base year. The SPF data is used to understand how market participants revise their forecasts for unemployment rate.

[11] All results are available from authors upon request.

[12] The mean SPF forecasts yielded qualitatively similar results.

2.4.3 Empirical Results

Labor Market Effects of Government Employment

Figures 2.2∼6 show the estimated impulse-response functions ($IRF_{1,j}$) given 1% increase in government employment (g_t) based on the VAR in (2.23). The solid line gives the point estimates. The dashed lines represent 90% confidence intervals, computed by nonparametric bootstrap based on 500 replications.[13] In all figures, panel (a) and (b) report estimation for the first and last 30-year sample periods: $1960Q1 \sim 1989Q4$ (SP1) and $1987Q4 \sim 2017Q3$ (SP2) respectively.

The response of private employment ($pjob_t$) and total employment ($tjob_t$) to the fiscal shock are displayed in figures 2.2 and 2.3. It should be noted that government employment shocks have *remarkably* different effects across two sub-samples. A significant and persistent increase in private and total employment can be observed only in SP1, whereas their responses have fallen substantially in SP2. In other words, increase in government employment was stimulating in the labor market during earlier sample periods but has become substantially weaker when more recent sample periods are employed.

Our IRFs imply the hypothesis of a structural break in the propagation mechanism of fiscal policy across time. To further detect the possible structural changes in the data generating process of $\mathbf{x}_t$, we conduct a fixed-size rolling window scheme. The first rolling window consists the initial $T_0(< T)$ observations, $\{\mathbf{x}_t\}_{t=1}^{T_0}$. Then we drop the start and add the end dates by one quarter to maintain the same size of the sample window until we obtain the last round IRFs estimated from $\{\mathbf{x}_t\}_{t=T-T_0+1}^{T}$, totalling $T - T_0 + 1$ sets of the IRF estimates.

Panel (c) and (d) of all figures in this section report estimates employing a 30-year ($T_0 = 120$ quarters) rolling window scheme.[14] Each grid point along the x-axis (Date) is the ending period of each rolling window indexed from $1989Q4$ to $2017Q3$. The y-axis (Year) is the time horizon (j) of the response function indexed from 0 to 5 years. The z-axis is the response ($IRF_{1,j}$) of each variable to 1% positive government employment shock. The surface graphs

[13] The 5^{th} and 95^{th} percentiles of the 500 response function estimates constitute the 90$\%$ confidence interval.

[14] We also implemented the same analysis with a 20-year window as well as a 40-year window scheme. Results are overall similar and are available upon requests.

in panel (c) of Figures 2.2 and 2.3 overall confirm structure breaks in the response of $pjob_t$ and $tjob_t$ over time. Strong positive responses are rapidly dragged down as the sample period moves forward. The close resemblance between private and total employment implies that total employment was pushed downward by substantially negative response of private employment.

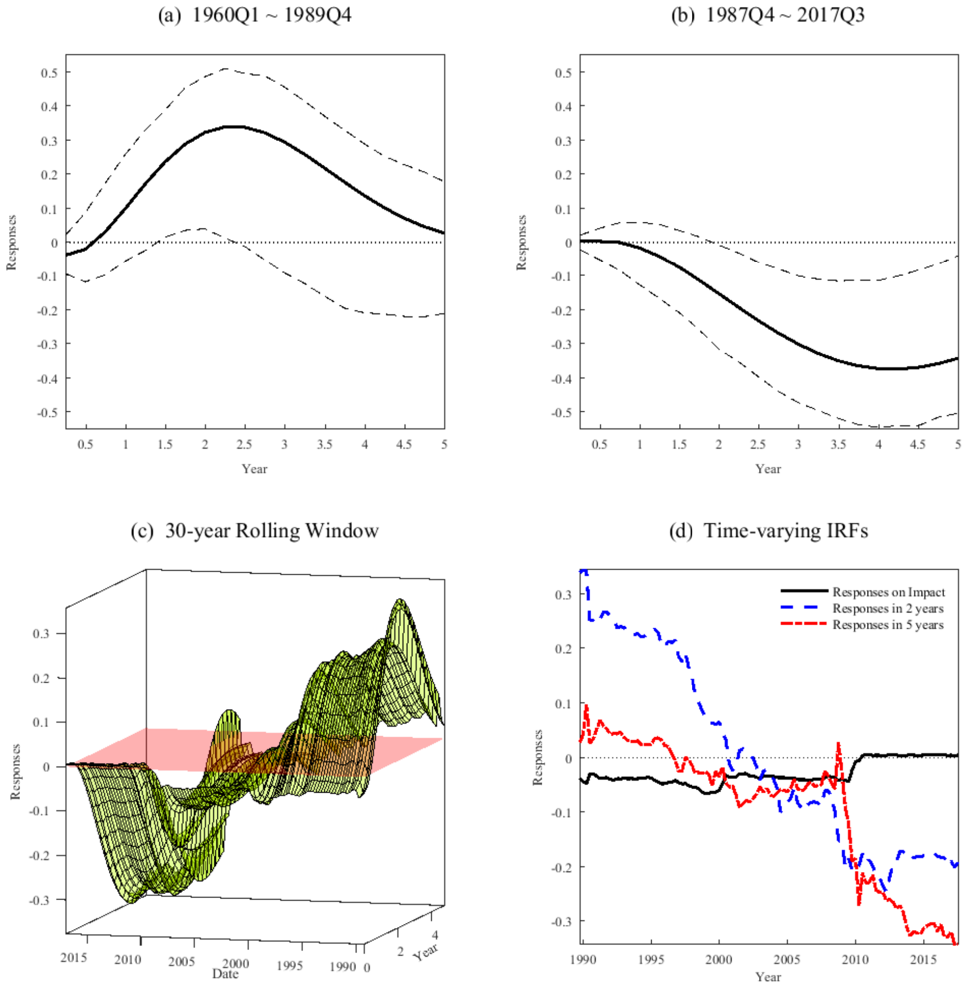
The time-varying responses of $pjob_t$ and $tjob_t$ to the fiscal shock are further highlighted in panel (d) of Figures 2.2 and 2.3, which provide the IRFs in the short-run to the long-run by dissecting panel (c) at $y = 0,\ 2,\ 5$ (years) of the y-axis from the right to the left. Responses of $pjob_t$ and $tjob_t$ on impact are relatively stable over time but their medium ($y = 2$) and long run ($y = 5$) responses clearly exhibit variations with a substantially downward trend over time, implying the weakening effectiveness of fiscal stimulus.

Similarly, differences across time in responses of unemployment rate ($urat_t$) and employment-population rate ($erat_t$) are remarkable, reported in Figures 2.4 and 2.5. In SP1 the unemployment rate falls significantly in response to an increase in government employment, whereas in SP2 the opposite is true. Correspondingly, employment-population rate increases persistently when the fiscal shock occurs in SP1 but falls to a negative region in SP2. The figures in the lower panel confirm stark rising in unemployment rate and declining in employment-population rate over time. These responses accord with findings of private and total employment regarding a weaker fiscal stimulus that are reported in Figures 2.2 and 2.3.

We also investigate how private wage (pw_t) reacts to the government employment shock. Figure shows a positive covariation between the government employment and private wage in SP1 while government employment shocks fail to raise the private wage in SP2. The rapid deteriorations of private wage across time can also be found in lower panel. Related to downward trend in private employment, the dynamics of private wage imply us that government hiring stimulates labor demand, driving up wages in private sector during earlier time. In more recent periods, however, it crowds out aggregate demand, lowering labor demand and therefore wages in private industries.

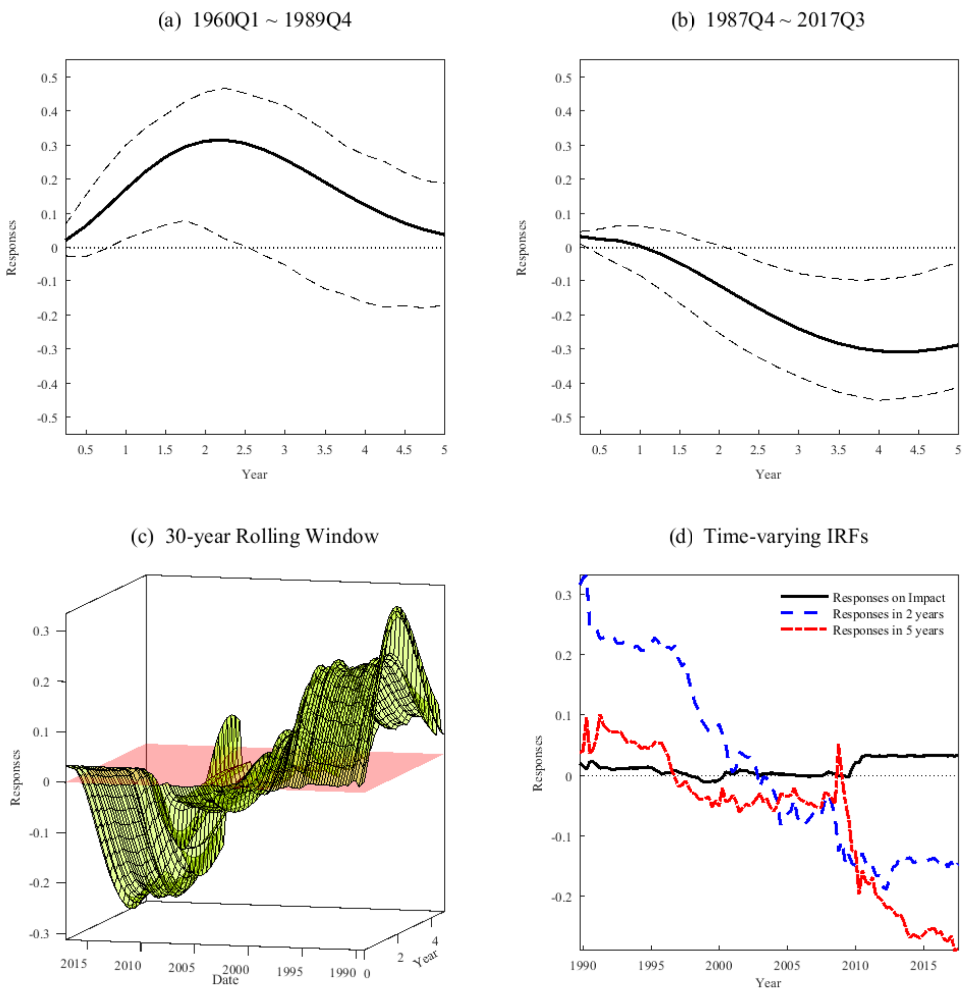
Overall, our findings reported above demonstrate that fiscal policy in the U.S. has become ineffective in stimulating the labor market with a comparison of both sub-samples. In particular, responses of all labor market variables to the government employment shock are align with

Figure 2.2: Private Employment Responses to the Government Employment Shock



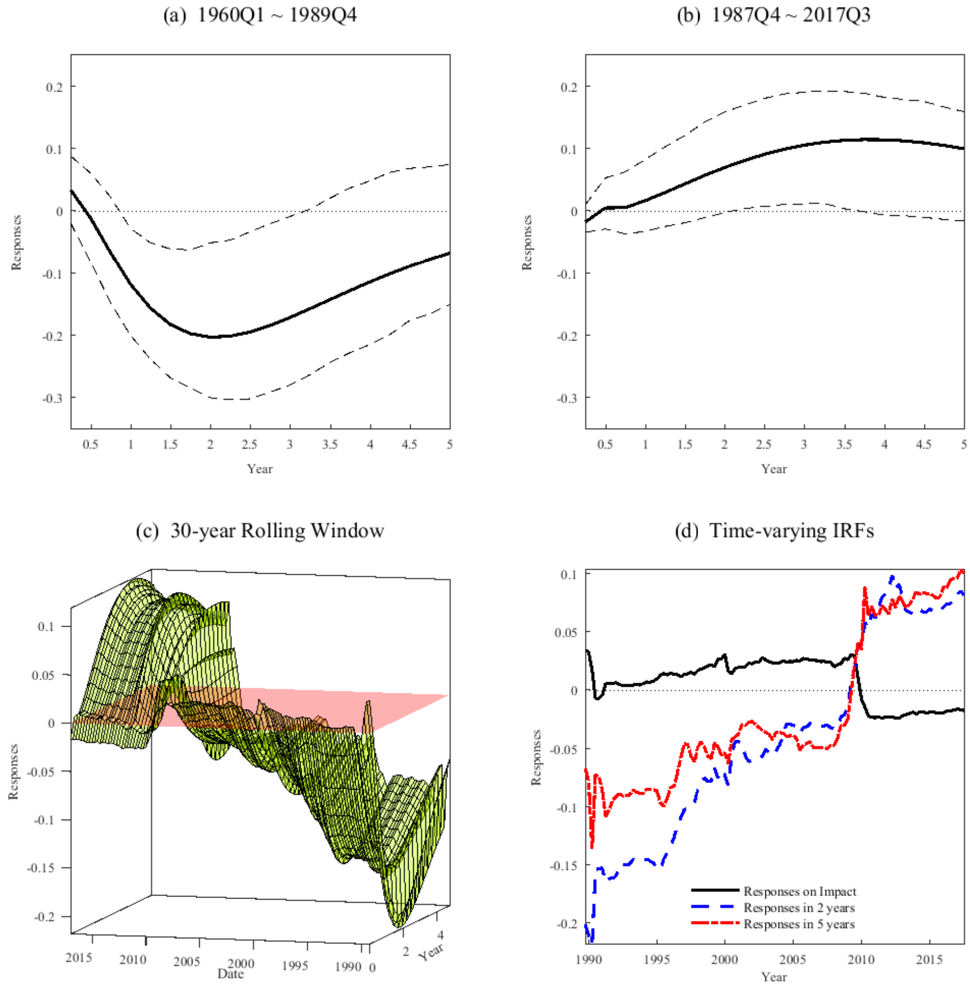
Note: We report the impulse-response function (IRF) estimates from $\mathbf{x}_t = [n_t^g, gdp_t, pjob_t, int_t, mon_t]'$ to a 1% government employment shock. Panel (a) and Panel (b) report the IRF estimates (solid) of the private jobs along with its 90% confidence bands (dashed) that were obtained from 500 bootstrap simulations with empirical distributions. Panel (c) reports an array of IRFs to the government employment shock with a 30-year fixed-size rolling window scheme. Panel (d) provides the IRFs in the short- to the long-run by dissecting the surface graph (panel (c)) at $y = 0,\ 2,\ 5$ (years) of the year-axis.

Figure 2.3: Total Employment Responses to the Government Employment Shock



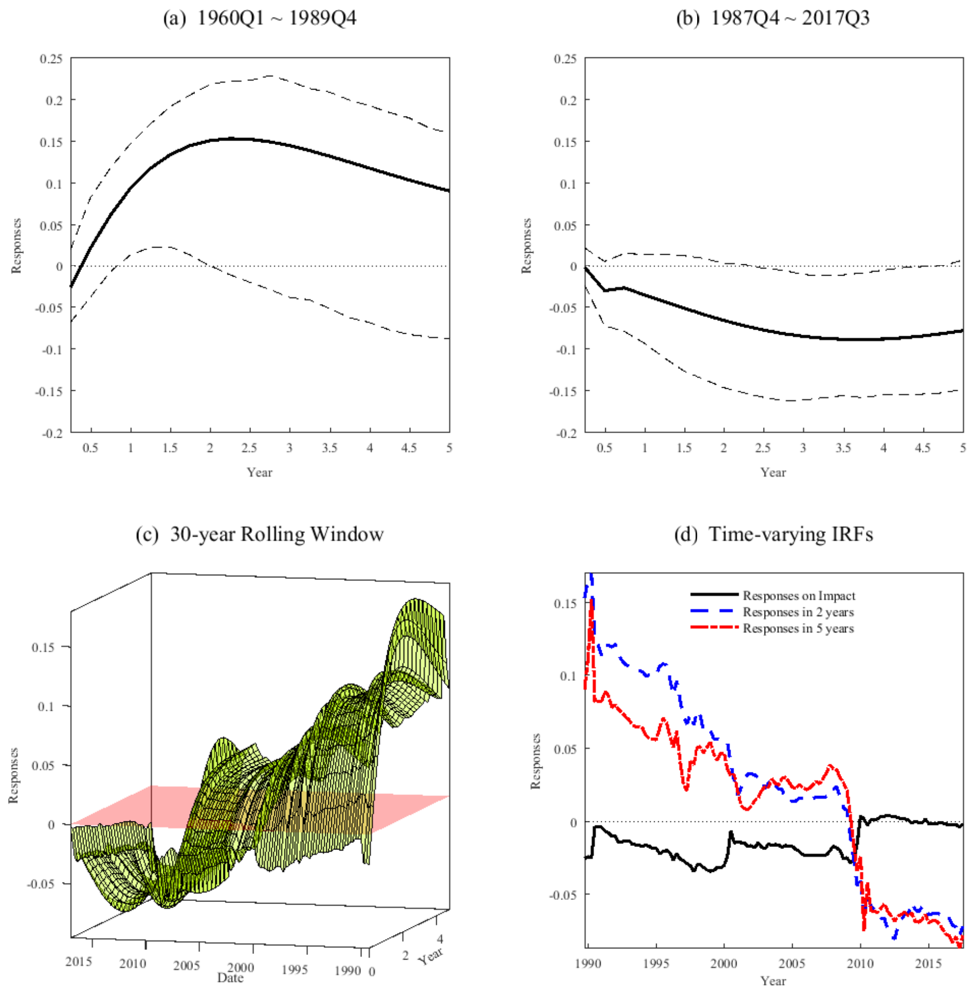
Note: We report the impulse-response function (IRF) estimates from $\mathbf{x}_t = [n_t^g, gdp_t, tjob_t, int_t, mon_t]'$ to a 1% government employment shock. Panel (a) and Panel (b) report the IRF estimates (solid) of private GDP along with its 90% confidence bands (dashed) that were obtained from 500 bootstrap simulations with empirical distributions. Panel (c) reports an array of IRFs to the government spending shock with a 30-year fixed-size rolling window scheme. Panel (d) provides the IRFs in the short- to the long-run by dissecting the surface graph (panel (c)) at $y = 0,\ 2,\ 5$ (years) of the year-axis.

Figure 2.4: Unemployment Rate Responses to the Government Employment Shock



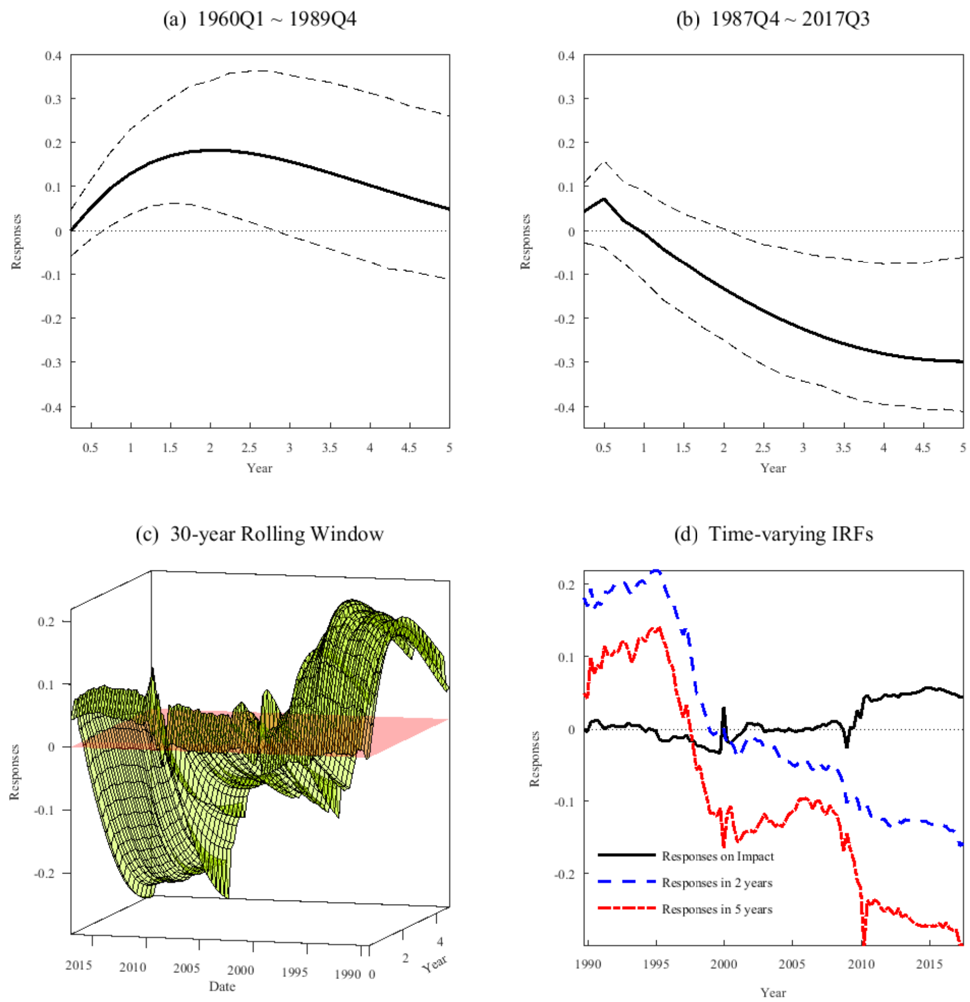
Note: We report the impulse-response function (IRF) estimates from $\mathbf{x}_t = [n_t^g, gdp_t, urat_t, int_t, mon_t]'$ to a 1% government employment shock. Panel (a) and Panel (b) report the IRF estimates (solid) of consumption along with its 90% confidence bands (dashed) that were obtained from 500 bootstrap simulations with empirical distributions. Panel (c) reports an array of IRFs to the government spending shock with a 30-year fixed-size rolling window scheme. Panel (d) provides the IRFs in the short- to the long-run by dissecting the surface graph (panel (c)) at $y = 0,\ 2,\ 5$ (years) of the year-axis.

Figure 2.5: Employment-population Rate Responses to the Government Employment Shock



Note: We report the impulse-response function (IRF) estimates from $\mathbf{x}_t = [n_t^g, gdp_t, erat_t, int_t, mon_t]'$ to a 1% government employment shock. Panel (a) and Panel (b) report the IRF estimates (solid) of investment along with its 90% confidence bands (dashed) that were obtained from 500 bootstrap simulations with empirical distributions. Panel (c) reports an array of IRFs to the government spending shock with a 30-year fixed-size rolling window scheme. Panel (d) provides the IRFs in the short- to the long-run by dissecting the surface graph (panel (c)) at $y = 0,\ 2,\ 5$ (years) of the year-axis.

Figure 2.6: Private Wage Responses to the Government Employment Shock



Note: We report the impulse-response function (IRF) estimates from $\mathbf{x}_t = [n_t^g, gdp_t, pw_t, int_t, mon_t]'$ to a 1% government employment shock. Panel (a) and Panel (b) report the IRF estimates (solid) of private wage along with its 90% confidence bands (dashed) that were obtained from 500 bootstrap simulations with empirical distributions. Panel (c) reports an array of IRFs to the government employment shock with a 30-year fixed-size rolling window scheme. Panel (d) provides the IRFs in the short- to the long-run by dissecting the surface graph (panel (c)) at $y = 0,\ 2,\ 5$ (years) of the year-axis.

stimulating fiscal policy in earlier sample periods. Conversely, fiscal policy began to lower employment and private wages and increase unemployment rate when more recent sample periods are employed, generating completely depressing fiscal policy.

The Role of Interest Rate in the Transmission of Government Employment

What does account for these apparent time-varying effectiveness in fiscal transmission? For this purpose, we firstly try to explore possible causes by empirically assessing the role of the interest rate channel. According to earlier findings described in our theoretical model, the prevailing monetary-fiscal policy regime is the first order of business for determining fiscal policy effects. According to Clarida et al. (2000), there is a significant change in the way the Fed conducted monetary policy pre-and post-Volcker's appointment as the Fed's Chairman in the third quarter of 1979. That is, real interest rate is expected to decline in response to the government employment shock in regime D (pre-Volcker era), while it rises in regime H (post-Volcker era).

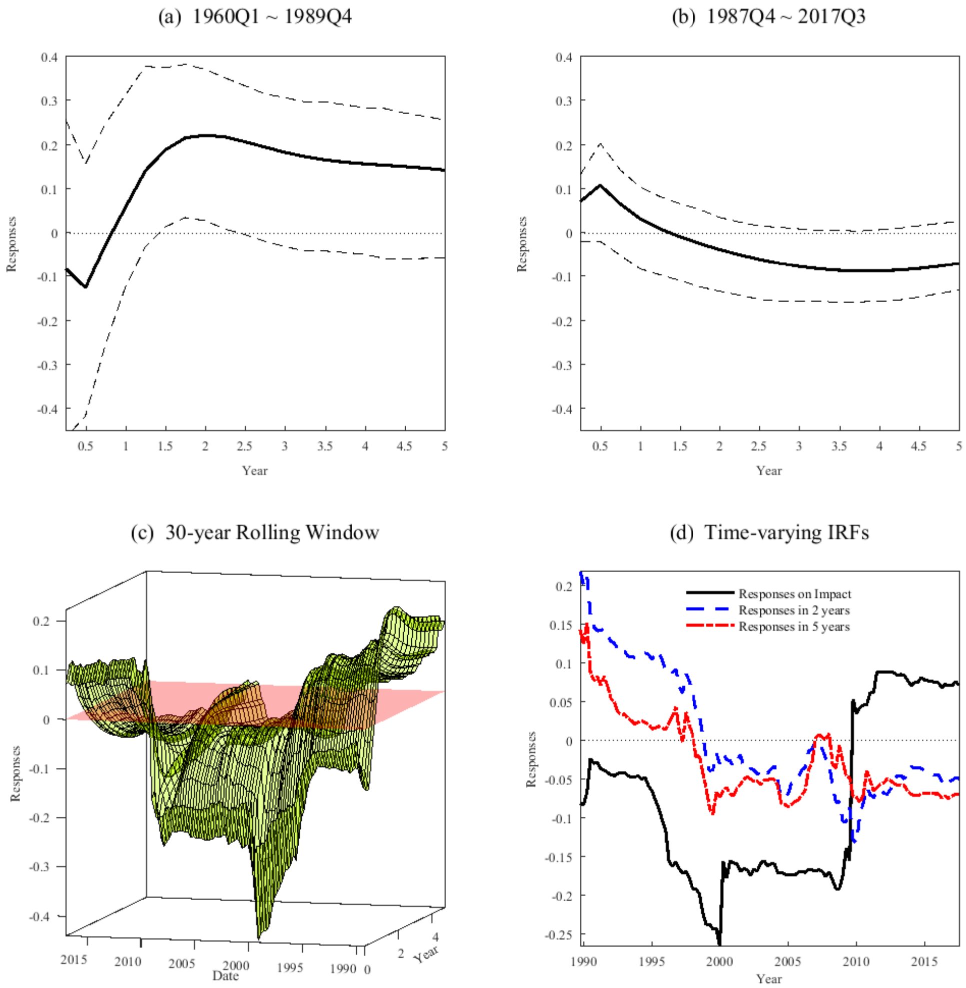
To assess the role of the real interest rate, we consider the VAR model (2.23) with $\mathbf{z}_t = [rffr_t \;\; mon_t]'$, where $rffr_t$ is the *ex-post* real federal funds rate (FEDFUNDS). [15] Our empirical evidence reported in Figure 2.7, however, is at odds with theoretical findings that there is a sizeable increase in the response of $rffr_t$ to the government employment shock after a very short decline at the beginning in SP1, while it rapidly falls below zero after about 1.5 years. Also, the downward trend across time can be observed in the lower panel. Due to the limited role of the real interest rate in the propagation of government employment shocks, we introduce a sentiment channel in the next section.

Sentiment Channel of Government Employment

There is a growing literature highlighted the role of sentiment as an important driver to variations in economic activity. Hall (1993) and Blanchard (1993) suggest that declines in consumer confidence play as an important contributor to economic recessions. Constructing a simple theoretical model, Guimaraes et al. (2016) shows that government spending affects the economic

[15] We used the CPI-based inflation rate to obtain the *ex-post* inflation.

Figure 2.7: Real FFR Responses to the Government Employment Shock



Note: We report the impulse-response function (IRF) estimates from $\mathbf{x}_t = [n_t^g, gdp_t, pjob_t, rint_t, mon_t]'$ to a 1% government employment shock. Panel (a) and Panel (b) report the IRF estimates (solid) of real interest rate along with its 90% confidence bands (dashed) that were obtained from 500 bootstrap simulations with empirical distributions. Panel (c) reports an array of IRFs to the government employment shock with a 30-year fixed-size rolling window scheme. Panel (d) provides the IRFs in the short- to the long-run by dissecting the surface graph (panel (c)) at $y = 0,\ 2,\ 5$ (years) of the year-axis.

activity through a confidence channel. Gillitzer and Prasad (2018) identifies the causal effect of sentiment on consumption. Bachmann and Sims (2012) proposes that the government spending shock generates output stimulus through consumer optimism in recessions, whereas the role of sentiment in normal times is minor. Rather, Kim and Jia (2017) argues that the shock seems to generate consumer *pessimism* in all phases of business cycle when properly detrended data are used.

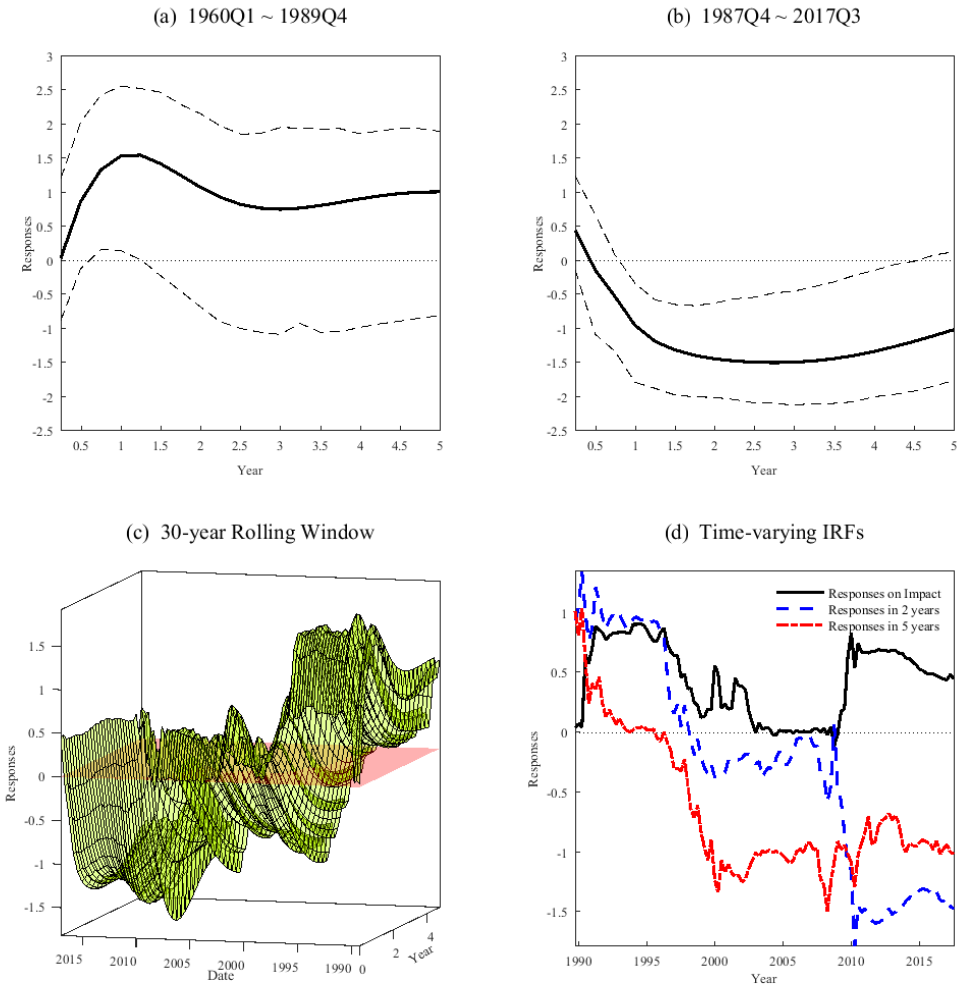
Recognizing a potentially critical role of sentiment, in this subsection we empirically show that the effectiveness of fiscal policy on the labor market is time-dependent because sentiment responses change over time. For this purpose, we augment the benchmark VAR model (2.23) with $sent_t$ to estimate the response of sentiment to the government employment shock. Recall that the location of $sent_t$ in the VAR does not matter for the fiscal policy effects as long as $sent_t$ is placed next to g_t.

In figure 2.8, we clearly see that government employment shock prompts a switch from an "optimism" to a "pessimism". That is, the sentiment response to the fiscal shock is positive in SP1 ($1960Q1 - 1989Q4$) but negative in SP2 ($1987Q4 - 2017Q3$). The downward trend of sentiment responses displayed in figures in the lower panel further verifies the time-varying dynamics of sentiment.

Based on these observations, we consider changes in sentiment as a clue to understand the weakening stimulus effects of fiscal policy on the labor market. The mechanism is: the government employment shock triggers consumer optimism, resulting in stimulating effects of fiscal policy during earlier sample periods. On the other hand, crowding-out effects of fiscal policy with later observations are consistent with consumer pessimism, depressing aggregate demand and therefore labor demand.[16] Next, we employ the Survey of Professional Forecasters (SPF) data to provide useful insights on the sentiment channel of fiscal policy.

[16] It might be the case that large sudden increases in government spending are perceived as a confirmation of an incoming recession in near future, generating consumer pessimism, which then results in a decrease in private spending.

Figure 2.8: Sentiment Responses to the Government Employment Shock



Note: We report the impulse-response function (IRF) estimates from $\mathbf{x}_t = [n_t^g, gdp_t, pjob_t, int_t, mon_t, sent_t]'$ to a 1% government employment shock. Note that the location of $sent_t$ is irrelevant given that g_t is placed first. Panel (a) and Panel (b) report the IRF estimates (solid) of sentiment along with its 90% confidence bands (dashed) that were obtained from 500 bootstrap simulations with empirical distributions. Panel (c) reports an array of IRFs to the government employment shock with a 30-year fixed-size rolling window scheme. Panel (d) provides the IRFs in the short- to the long-run by dissecting the surface graph (panel (c)) at $y = 0,\ 2,\ 5$ (years) of the year-axis.

2.5 Understanding Changes in Sentiment through the Lens of the SPF

In this section, we investigate the time-varying effects of fiscal policy on the labor market via the sentiment channel by employing the Survey of Professional Forecasters (SPF) data. We're particularly interested in the relationship between one-quarter-ahead government spending growth forecasts and one-year-ahead changes in unemployment rate forecasts, which helps explain how people in private sector update their economic prospects when the government conducts new fiscal policy. [17]

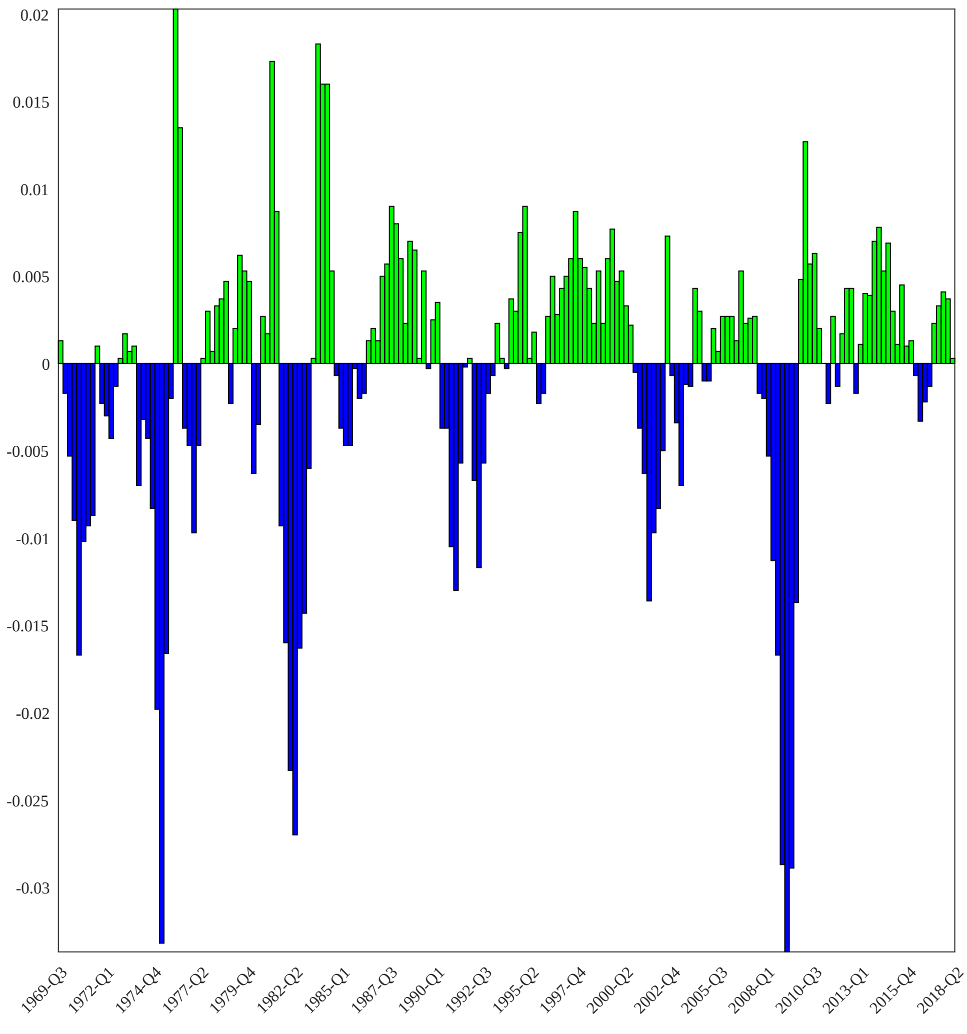
2.5.1 Systematic Forecast Errors

Let $\gamma_{x_t}^{SPF}(j+1) = x_{t+j}^{SPF} - x_{t-1}^{SPF}$ be the SPF growth rate forecast of (logged) x_t over $j+1$ quarters by means of information available at time $t-1$. The associated $j+1$-quarter-ahead realized counterpart is denoted by $\gamma_{x_t}(j+1) = x_{t+j} - x_{t-1}$. The SPF forecast error is defined as $\hat{\gamma}_{x_t}(j+1) = \gamma_{x_t}^{SPF}(j+1) - \gamma_{x_t}(j+1)$. Note that we do not square forecast errors because the sign of the errors delivers important information. The forecast errors of changes in unemployment rate over 5 quarters, $\hat{\gamma}_{urat_t}(5)$, are presented in Figure 2.9. It's noteworthy that there is a change in behavior in private sector experts' forecast errors. That is, they have a tendency to under-predict ($\hat{\gamma}_{urat_t}(5) < 0$) unemployment rate before 1980s, and predominantly over-predict it afterwards except for the period of 2008 financial crisis.

We conjecture that the systemic forecast errors seem to coincide with changes in the Federal Reserve's interest rate setting behavior when Paul Volcker was appointed as Chairman in $1979Q3$. Before Volcker, private forecasters primarily stayed optimistic forecasts of unemployment rate when the central bank conducts accommodative monetary policy, coordinated well with fiscal policy. On the other hand, they construct pessimistic forecasts since Volcker when the stance of monetary policy had turned hawkish. The large negative forecast errors around 2008 imply large forecast bias, which is closely related with the high uncertainty during the Great Recession.

[17] See the data description section for a detailed explanation on how these data are constructed.

Figure 2.9: SPF Forecast Errors for Changes in Unemployment Rate



Note: We report the 5-quarter ahead SPF forecast errors for changes in unemployment rate.

2.5.2 Time-varying Forecasts and Monetary Policy Stance

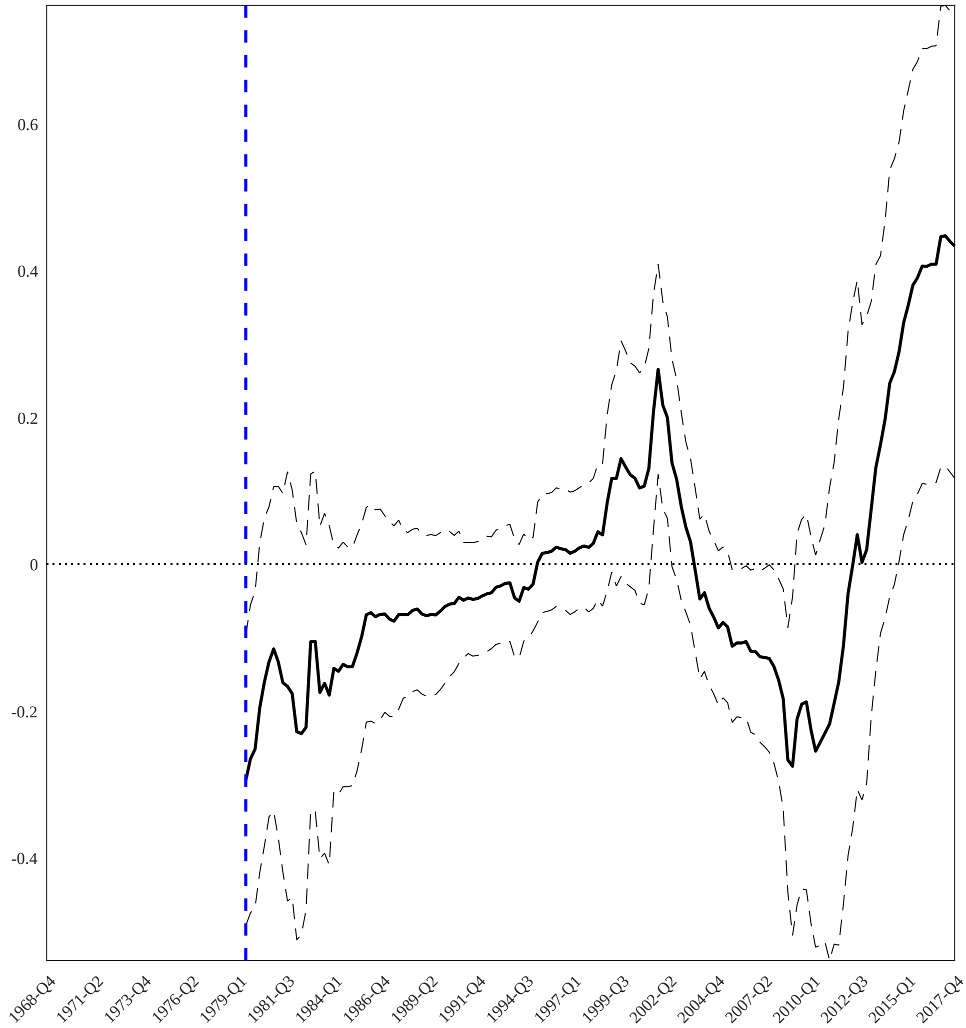
To investigate the possibility of the structural break in the stance of monetary policy, we conduct the following fixed-size rolling window regression

$$\gamma_{urat_t}^{SPF}(5) = \alpha + \beta\gamma_{gt}^{SPF}(1) + \varepsilon_t \tag{2.25}$$

The idea involved in this regression is: when forecasters receive new information on government spending growth, $\gamma_{gt}^{SPF}(1)$, the relationship between $\gamma_{gt}^{SPF}(1)$ and their long-run forecasts of changes in unemployment rate, $\gamma_{urat_t}^{SPF}(5)$, represented by β, would disclose their beliefs about the effectiveness of fiscal policy on the labor market. Positive value of β reflects optimism of forecasters on the impact of fiscal stimulus. Otherwise, β will be close to zero or even negative if they become less optimistic or pessimistic.

The time-varying estimates of equation (2.25) are reported in Figure 2.9. The size of each rolling window is set to 44-quarter so that the first rolling window sample corresponds to pre-Volcker era from $1968Q4$ to $1979Q3$. The point estimates are shown with the 90% confidence bands that are obtained from the normal approximation. The first estimate of $\hat{\beta}$ is -0.2949, significant at the 5% level. As observations from the post-Volcker era are added in the estimation, the value of $\hat{\beta}$ rapidly increases. Meanwhile, confidence bands become much wider, implying structural break in $\hat{\beta}$ since the Fed implemented aggressive monetary policy against inflation, which may diminish market participants' confidence on the effectiveness of fiscal policy. $\hat{\beta}$ continuously increases until the early 2000s when Mr. Greenspan cut the Fed funds rate to an extremely low level to combat the 2001 recession due to burst of the dot-com bubble. Adoption of accommodative monetary policy results in sharp decline in the value of $\hat{\beta}$. During the Great Recession, the point estimates of $\hat{\beta}$ continue to stay low as the Fed conducted extremely accommodative monetary policy with three rounds of quantitative easing (QE). However, wide confidence bands mirror high degree of uncertainty when the interest rate was constrained by the zero-lower-bound (ZLB). After that, $\hat{\beta}$ quickly jump up when the Fed began to raise its key interest rate. Taken together, Figures 2.9 and 2.10 provide strong evidence of time-varying adjustment of sentiment through the lens of the SPF.

Figure 2.10: LS Estimates for β with a Fixed Size Rolling Window Scheme



Note: We report the LS estimates $\hat{\beta}$ for β over time with a 44-quarter fixed size rolling window so that the initial point estimate corresponds to the pre-Volcker era ($1968Q4 \sim 1979Q3$). We obtained the 90% confidence bands (dashed lines) via the normal approximation.

2.6 Conclusion

In this paper we provide a series of analysis of the effectiveness of government employment on the labor market. We essentially contribute to the literature in three aspects. First, we add to the existing work that government employment has become ineffective in stimulating labor market conditions due to lack of coordination between monetary and fiscal policy. Second, we try to explain the time-varying effectiveness of fiscal policy by proposing a sentiment channel. Last, we employ the SPF data to extract important information about the sentiment channel.

We first of all present a New Keynesian model with two distinct policy regimes. The theoretical results demonstrate that an expansionary government employment shock stimulates the labor market only when the central bank adopts dovish monetary policy. To the contrast, hawkish monetary policy, conflicted with the fiscal stimulus, results in an increase in the real interest rate, crowding out total employment. We then provide empirical evidence on the response of key labor market variables to an increase in government employment. We compare these responses to our NK model to confirm the time-varying effects of fiscal policy on the labor market under different policy regimes. However, we observe a negligible role of the real interest rate in the transmission of fiscal policy, which is at odds with our theoretical prediction.

We suggest sentiment channel as an alternative propagation mechanism of fiscal policy. To see this, we use novel statistical approach with the Survey of Professional Forecasters data to investigate how market participants revise their forecasts of unemployment rate when they receive new information on fiscal actions. Given positive innovations in government spending, forecasters are substantially more optimistic about labor market conditions when the central bank maintains dovish monetary policy stance. On the other hand, it induces a wave of pessimism in an environment of expansionary fiscal policy and hawkish monetary policy, which depresses the aggregate demand and thus raises unemployment rate.

Chapter 3

On the Persistence of Forecast Errors

3.1 Introduction

It has been found widely that professional forecasters tend to make persistent forecast errors using different survey forecast data. Inflation forecasting has been studied most. A lot of researchers find strong tendencies for the forecasters to under-predict inflation. Similar patterns in prediction of real variables are also observed. For example, finding an optimistic bias in real GDP growth forecasts is a frequent feature. See, among others, Zarnowitz (1985), Orphanides (2002), Timmermann (2007) and Genberg and Martinez (2014). It's noteworthy that biases may vary over time. Some literature have claimed that systematic under-prediction of inflation in the 1970s and over-prediction of inflation afterwards indicate a shift in forecasters' behavior pre- and post-1980s. See, among others, Staiger et al. (1997), Croushore (1998), Capistrán (2008) and Capistrán and Timmermann (2009). Romer and Romer (2000) also suggests that all forecasts are irrational if samples are restricted to start from 1980 when there is a large monetary regime change.

A broad range of studies attempts to explain the observed forecast errors. The main argument is whether the forecaster is irrational or the loss function is asymmetric. Some scholars propose rationalizing biased forecasts based on strategic models. Kilian and Manganelli (2006, 2007) conclude that inflation forecasts are found to be rational in terms of asymmetric loss that costs associated with deflation and excessive inflation are different. Elliott et al. (2008) finds that both output and inflation forecasts are consistent with rationality under asymmetric loss. Capistrán (2008) demonstrates that asymmetric preferences of the Fed implies opposite cost of over and under predicting inflation before and after Volcker era. On the other hand, however, others propose irrational expectations based on behavioral models. Ehrbeck and Waldmann (1996) argues that empirical evidence reject strategic bias and are consistent with irrational expectations (forecasters are sincerely overconfident). In addition, Primiceri (2006) suggests that policy-makers' learning dynamics can account for over-optimism during the 1960∼1970s and over-pessimism in the early 1980s. Laster et al. (1999) claims that forecast publicity may induce professional forecasters to produce biased forecasts.

In this paper, we construct forecasts of real GDP growth, unemployment growth and inflation over a one-year horizon applying cumulative sum and the law of iterated projection for their quarter-over-quarter forecasts from two different surveys: (1) the Greenbook forecasts, which gathers forecasts from the research staff at the Board of Governors, (2) the Survey of Professional Forecasters(SPF), which looks at forecasts from economists in the private sector.[1] To understand how forecasters revise their economic prospects, we recover the one-year-ahead forecast errors. Aligned with most literature, we confirm systematic forecast errors, which prove existence of forecast bias. The serial correlation test of forecast errors further demonstrate that there exists significantly persistent forecast bias in both the private sector and Federal Reserve forecasters' expectations. In addition, we noticed that there are two sharp changes in the sign of forecast errors for real GDP growth forecasts and inflation forecasts: one around 1980 and the other around 2000.

By now, however, it is still controversial what accounts for persistent forecast bias and why forecasters behaved differently over time. Capistrán (2008) proposed asymmetries in the Fed's objective function implied by inflation forecast to account for the systematic forecast bias. However, his argument cannot be applied to explain similar patterns found in private sector forecasts and forecasts for real variables. We conjecture that the time-varying relationship between fiscal and monetary policy (Kim and Zhang (2018)) may explain how forecasters formulate expectations. That is, forecasters tend to generate more optimistic predictions when

[1]The data on for example unemployment rate and inflation are very noisy, so we are focusing on if forecasters are correct about the overall trend. See Bryan and Cecchetti (1994) for a discussion of the noise in inflation data.

fiscal and monetary policies are well coordinated. When policies are conflicted with each other, however, they often formulated more pessimistic forecasts.

3.2 Bias in Forecasts

3.2.1 Data Descriptions

This paper examines how forecasters revise their economic prospects in both the private sector and Federal Reserve. For this purpose, we employ forecasts from both the Survey of Professional Forecasters (SPF) and the Greenbook data. In particular, we recover forecast errors for real GDP growth, unemployment growth and inflation for the U.S. over one year following the period when the survey was conducted.[2] All data are obtained from the Philadelphia Fed website. The sample for median SPF forecasts data starts with forecasts made in the fourth quarter of 1968 and ends with forecasts made in the second quarter of 2018.[3] The projections from the Greenbook are released to the public with a lag of five years by rule, so the sample for Greenbook forecasts are in the period between $1969Q4$ and $2012Q4$.[4] We measure inflation as the change in both the GDP deflator and CPI.

There's a discussion on whether real "time" or "final" data are used as actual values for comparison with forecasts. In this paper, fully revised data obtained from the Federal Reserve Economic Data (FRED) is employed as a proxy for true values. These revisions bring the data closer to the "true" values that forecasters would like to have predicted. Throughout the paper, all observations are quarterly frequency. In what follows, we describe and examine forecast errors of each variable.

3.2.2 Measuring Forecast Errors

We define h-quarter-ahead forecast error made at time t of real GDP growth (y), unemployment growth (u) and inflation (π) as

$$e^x_{t+h} = x^f_{t+h} - x_{t+h}$$

[2] We also report short-run (one-quarter-ahead) forecast errors, seen in Appendix.
[3] The mean SPF forecasts yielded qualitatively similar results.
[4] We chose values from the latest Greenbook published within each quarter.

where x^f_{t+h} for $x = \{y, u, \pi\}$ and $f = \{spf, gb\}$ is the h-quarter-ahead forecast of the variable x_t, while x_{t+h} denotes the realized counterpart of x^f_{t+h}.[5] Using the law of iterated expectation, x^f_{t+h} is calculated as cumulative sum of quarter-over-quarter forecasts. For real GDP growth, positive forecast errors indicate optimistic prediction while negative forecast errors imply pessimistic prediction. For unemployment growth and inflation, optimistic prediction is represented by negative forecast errors.

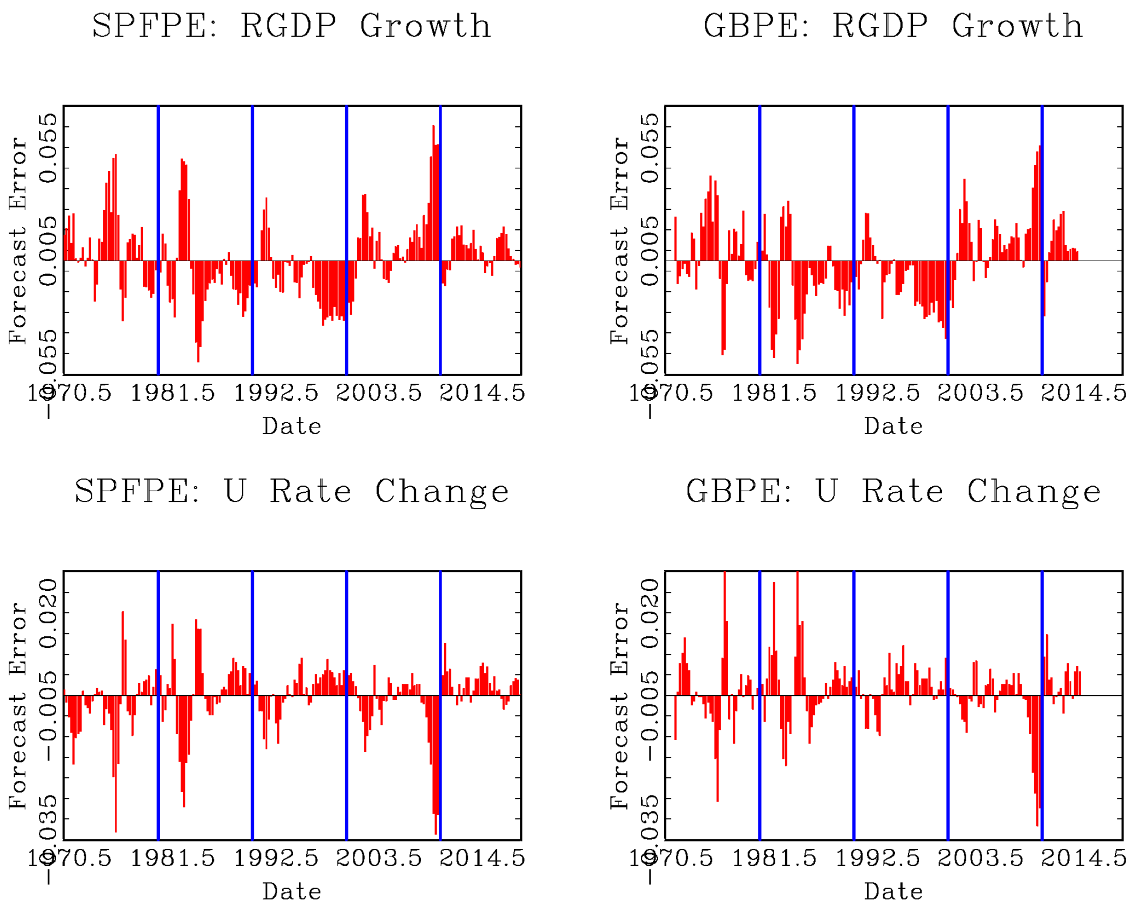
The calculated forecast errors are presented in Figures 3.1$\sim$ 3.2. For each quarter t, the figures show the forecast errors from quarter t to quarter $t + 4$. Some interesting observations are as follows. As is evident, both SPF and Greenbook forecasts of all variables provide evidence of systematic forecast errors. For inflation, the forecast errors have switched from being frequently negative in the 1970s to consistently positive from 1980 to the early 2000s, after which the forecast errors are mostly negative except for a short period of positive forecast errors due to Great Recession.[6] Similar pattern can be found in forecasts of real GDP growth: the samples pre-1980 have systematic positive forecast errors and for the sample after-1980 forecast errors reveal systematic negative errors up until 2000. In 2000s, the forecast errors become systematically positive although the burst of the financial crisis discounted the positive values a lot. Forecast errors of unemployment growth are overall inversely related to those of real GDP growth.

In addition, two sharp changes in the sign of these systematic forecast errors can be observed in the full sample: one around 1980 and a second around 2000. That is, both the private sector and Federal Reserve forecasters tend to give optimistic predictions during the pre-Volcker era ($1968Q4 - 1979Q2$), while they predominantly make pessimistic predictions during the post-Volcker era until the early 2000s. During the 2000s, forecasts become overall optimistic till the beginning of the Great Recession, followed by much weaker optimistic predictions.

[5] x^f_{t+h} is calculated as the partial sum of quarterly growth rate using the law of iterated method.

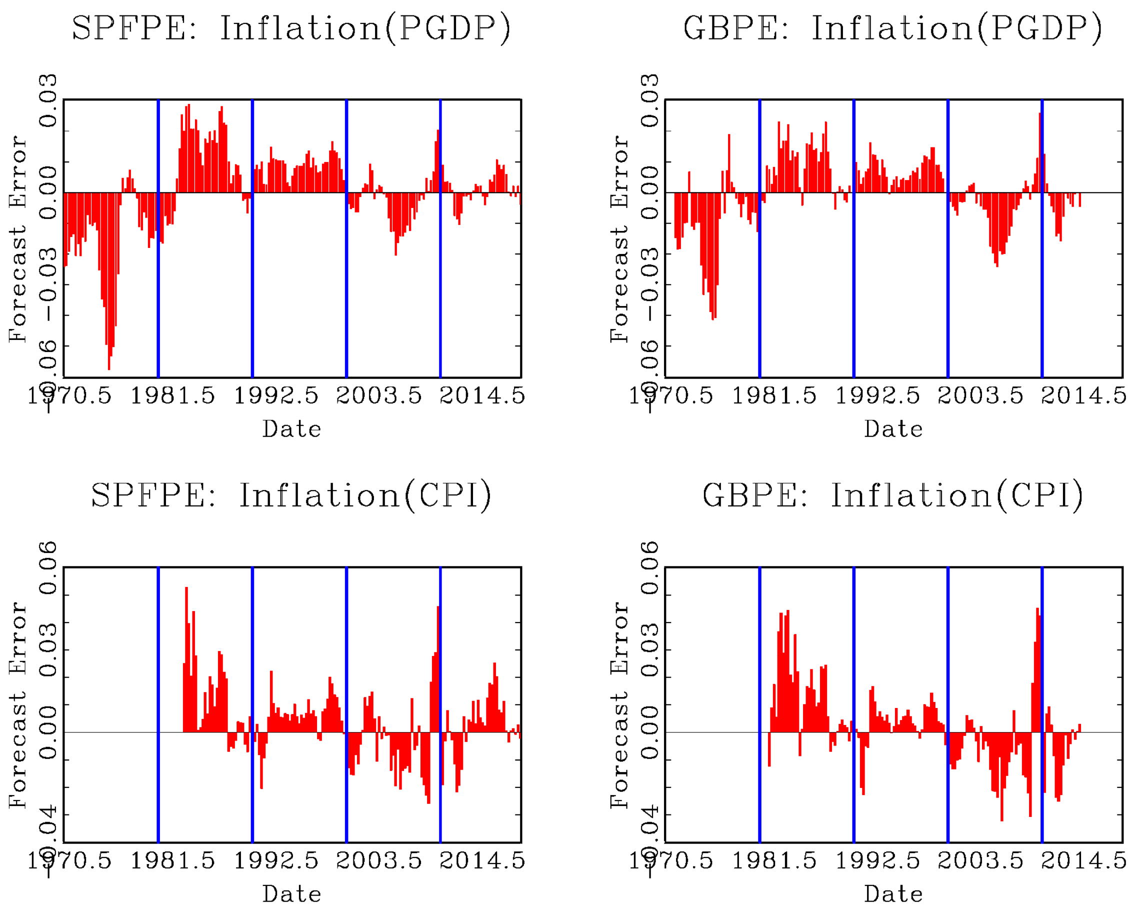
[6] Data for CPI-based inflation of both SPF and Greenbook are not available during the pre-Volcker period.

Figure 3.1: Prediction Errors on Real Variables



Note: We report the 5-quarter ahead prediction errors of the Survey of Professional Forecasters (SPF) and of the Greenbook, respectively.

Figure 3.2: Prediction Errors on Inflation



Note: We report the 5-quarter ahead prediction errors of the SPF and of the Greenbook, respectively.

3.2.3 Persistence of Forecast Errors

In this subsection, we employ the median unbiased estimator (MUE) Hansen (1999) to test for serially correlation of the forecast errors calculated above. Table 3.1 reports the estimation results. $\hat{\alpha}$ denotes MUE persistence parameter from the AR(1) specification. To correct for median bias for the point estimate and the 95% confidence band, we implemented 10,000 bootstrap simulations at each of the 100 fine grid points around the least squares point estimate. Not surprisingly, the $\hat{\alpha}$ statistics provide evidence of significant persistence on serial correlation in one-year-ahead forecast errors for all variables. We also report estimates for two-quarter-ahead forecast errors. It should be noted that $\hat{\alpha}$ values increase strongly with the increase in the predictive horizon. Therefore, the test demonstrates that there exists significant persistent forecast bias for forecasters in both the private sector and Federal Reserve.

One related interesting question is whether the Federal Reserve has superiority in forecasting performance than commercial forecasters. For example, Romer and Romer (2000) claimed that the Federal Reserve's inflation forecasts are more accurate than commercial forecasters'. For evaluation criteria, we use the ratio of the root mean squared forecast error ($RRMSFE$), which is defined as the root mean squared forecast error ($RMSFE$) from SPF divided by $RMSFE$ from Greenbook. Note that SPF outperforms Greenbook when $RRMSFE$ is less than 1. $RRMSFE$ estimates are also reported in Table 1. We note that Greenbook outperforms SPF for both short-run (two-quarter) and long-run (one year) forecast horizons. The $RRMSFE$ estimates are greater than one for all variables.

Table 3.1: Persistence Parameter Estimation

	5-quarter ahead Prediction Errors			2-quarter ahead Prediction Errors		
	$\hat{\alpha}^{SPF}$	$\hat{\alpha}^{GB}$	$RRMSFE$	$\hat{\alpha}^{SPF}$	$\hat{\alpha}^{GB}$	$RRMSFE$
Δy_t	0.852 [0.774, 0.934]	0.786 [0.690, 0.883]	1.0248	0.498 [0.374, 0.622]	0.343 [0.200, 0.485]	1.0576
Δu_t	0.775 [0.683, 0.871]	0.678 [0.565, 0.791]	1.0197	0.574 [0.457, 0.692]	0.212 [0.065, 0.360]	1.1789
Δdp_t	0.947 [0.896, 1.009]	0.897 [0.826, 0.978]	1.2219	0.714 [0.613, 0.815]	0.581 [0.459, 0.706]	1.1476
Δcp_t	0.714 [0.596, 0.833]	0.753 [0.636, 0.873]	1.0070	0.227 [0.061, 0.380]	0.140 [−0.038, 0.301]	1.1595

Note: $\hat{\alpha}$ denotes the median unbiased estimate (Hansen, 1999) of the persistence parameter from the AR(1) specification. To correct for median bias for the point estimate and the 95% confidence band, we implemented 10,000 bootstrap simulations at each of the 100 fine grid points around the least squares point estimate. The $RRMSPE$ is the ratio of $\frac{\sqrt{\sum_{t=1}^{T}(e^x_{spf,t+h})^2/T}}{\sqrt{\sum_{t=1}^{T}(e^x_{gb,t+h})^2/T}}$ where e^x_{t+h} denotes h-quarter ahead forecast errors for variable x at time t.

3.2.4 What Accounts for Systematic Forecast Errors

The results presented so far demonstrate persistent forecast bias for forecasters in both the private sector and Federal Reserve. Moreover, we noticed that there are two sharp changes in the sign of forecast errors for real GDP growth forecasts and inflation forecasts: one around

1980 and the other around 2000. In particular, there have been strong tendencies for forecasters to make persistently optimistic predictions before 1980, pessimistic predictions during 1980∼2000, and optimistic predictions in 2000s. Capistrán (2008) claimed that asymmetries in the Fed's objective function implied by inflation forecast might account for the cause of such seemingly forecast irrationality. However, this argument cannot answer why private sector forecasters also create similar systematic forecast errors. What's more, we find that the systematic forecast errors exist in not only inflation but real variables (output growth and unemployment growth) as well.

We conjecture that the systematic forecast errors with changed sign might be closely related to the time-varying relationship between fiscal and monetary policy. As is pointed out by Clarida et al. (2000), the Fed's interest rate setting behavior has changed when Paul Volcker took office in the third quarter of 1979. In the early 1980s, Paul Volcker, the chairman of the Federal Reserve, shifted Fed policy to aggressively raise the interest rate in a successful attempt to decrease inflation. Under such circumstances, forecasters were prone to generate pessimistic predictions when observing hawkish monetary policy conflicted with fiscal policy. On the other hand, however, forecasters are likely to formulate more optimistic economic prospects when accommodative monetary policy is well coordinated with fiscal policy. This may correspond to another monetary policy regime, which has been in place through Greenspan Fed chairmanship during the early 2000s, when the U.S. economy was hit by the "dotcom" crash. To combat the recession, the Fed adopted dovish monetary policy by reducing the federal funds rate substantially to spur economic activity.

3.3 Concluding Remarks

The most important finding of this paper is that there exists persistent systematic forecast bias for forecasters in both the private sector and Federal Reserve. This forecast bias can be found in inflation, real GDP growth as well as unemployment growth. Besides, two sharp changes in the sign of forecast errors can be observed: one around 1980 and second around 2000. We conjecture that the persistent forecast bias with time-varying signs might be driven by regime-switching in fiscal and monetary policy. That is, forecasters seem to generate more optimistic predictions when policies are well coordinated with each other, while pessimistic predictions are likely to occur when the Fed adopts a hawkish stance.

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Appendices

Appendix A

The Appendix A lists the equilibrium conditions, steady state, and log-linearized system used for the simulation in chapter 1.

A1. Equilibrium Conditions

• The first order conditions of the household

$$
\begin{aligned}
\lambda_t &= \frac{1}{c_t^* - hc_{a,t-1}^*} \\
c_t^* &= c_t + \alpha_g g_t \\
{R_t}^{-1} &= \beta E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \frac{1}{\pi_{t+1}} \right) \\
a'(\mu_t) &= \left(1 - \tau^k\right) r_t^k \\
q_t &= \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \left[\left(1 - \tau^k\right) \mu_{t+1} r_{t+1}^k - a(\mu_{t+1}) + q_{t+1}(1-\delta) \right] \right\} \\
1 &= q_t \left[1 - S\left(\frac{i_t}{i_{t-1}} \right) - S'\left(\frac{i_t}{i_{t-1}} \right) \frac{i_t}{i_{t-1}} \right] + \beta E_t q_{t+1} \frac{\lambda_{t+1}}{\lambda_t} S'\left(\frac{i_{t+1}}{i_t} \right) \left(\frac{i_{t+1}}{i_t} \right)^2 \\
\Omega_t &= \lambda_t w_t n_t \left(\pi_{w,t}^*\right)^{1-\theta_w} + \omega_w \beta E_t \left(\frac{\pi_t^{\iota_w} \bar{\pi}^{1-\iota_w}}{\pi_{t+1}} \right)^{1-\theta_w} \left(\frac{\pi_{w,t+1}^*}{\pi_{w,t}^*} \frac{w_{t+1}}{w_t} \right)^{\theta_w - 1} \Omega_{t+1} \\
\Omega_t &= \mathcal{M}^w \varrho \left(\pi_{w,t}^*\right)^{-\theta_w(1+\eta)} n_t^{1+\eta} + \omega_w \beta E_t \left(\frac{\pi_t^{\iota_w} \bar{\pi}^{1-\iota_w}}{\pi_{t+1}} \right)^{-\theta_w(1+\eta)} \left(\frac{\pi_{w,t+1}^*}{\pi_{w,t}^*} \frac{w_{t+1}}{w_t} \right)^{\theta_w(1+\eta)} \Omega_{t+1}
\end{aligned}
$$

• The wage index evolves as:

$$
1 = \omega_w \left(\frac{w_{t-1}}{w_t} \frac{\pi_{t-1}^{\iota_w} \bar{\pi}^{1-\iota_w}}{\pi_t} \right)^{1-\theta_w} + (1-\omega_w) \left(\pi_{w,t}^*\right)^{1-\theta_w}
$$

• The first order conditions of the firm

$$
\begin{aligned}
0 &= (1-\theta_p) F_{2,t} + \theta_p F_{1,t} \\
F_{1,t} &= \lambda_t mc_t y_t + \omega_p \beta E_t \left(\frac{\pi_t^{\iota_p} \bar{\pi}^{1-\iota_p}}{\pi_{t+1}} \right)^{-\theta_p} F_{1,t+1} \\
F_{2,t} &= \lambda_t \pi_t^* y_t + \omega_p \beta E_t \left(\frac{\pi_t^{\iota_p} \bar{\pi}^{1-\iota_p}}{\pi_{t+1}} \right)^{1-\theta_p} \left(\frac{\pi_t^*}{\pi_{t+1}^*} \right) F_{2,t+1} \\
\frac{w_t}{r_t^k} &= \frac{1-\alpha}{\alpha} \frac{\mu_t k_{t-1}}{n_t} \\
mc_t &= \alpha^{-\alpha} (1-\alpha)^{\alpha-1} w_t^{1-\alpha} \left(r_t^k \right)^{\alpha}
\end{aligned}
$$

• The price level evolves:

$$
1 = \omega_p \left(\frac{\pi_{t-1}^{\iota_p} \bar{\pi}^{1-\iota_p}}{\pi_t} \right)^{1-\theta_p} + (1-\omega_p) (\pi_t^*)^{1-\theta_p}
$$

• Monetary authority follow its Taylor rule

$$
R_t = (R_{t-1})^{\psi_r} \left[\bar{R} \left(\frac{\pi_t}{\bar{\pi}} \right)^{\phi_\pi} \left(\frac{y_t}{\bar{y}} \right)^{\phi_y} \right]^{1-\psi_r}
$$

• Government budget constraint:

$$
\frac{B_t}{P_t} + \tau^n w_t n_t + \tau^k r_t^k u_t k_{t-1} = \frac{R_{t-1} B_{t-1}}{P_t} + g_t + tr
$$

where

$$
g_t = g_{t-1}^{\psi_g} \left[\bar{g} \left(b_{t-1}/\bar{b} \right)^{-\gamma_g} \right]^{1-\psi_g} \nu_{g,t}
$$

• Markets clear:

$$
\begin{aligned}
y_t &= \frac{(u_t k_{t-1})^{\alpha} (n_t)^{1-\alpha}}{\xi_{p,t}} \\
y_t &= c_t + i_t + g_t + a(u_t) k_{t-1}
\end{aligned}
$$

where

$$
\begin{aligned}
a(u_t) &= \zeta_1 (u_t - 1) + \frac{\zeta_2}{2} (u_t - 1)^2 \\
\xi_{p,t} &= \omega_p \left(\frac{\pi_{t-1}^{\iota_p} \bar{\pi}^{1-\iota_p}}{\pi_t} \right)^{-\theta_p} \xi_{p,t-1} + (1-\omega_p) (\pi_t^*)^{-\theta_p}
\end{aligned}
$$

and

$$\begin{aligned}
k_t &= (1-\delta) k_{t-1} + \left[1 - S\left(\frac{i_t}{i_{t-1}}\right)\right] i_t \\
S\left(\frac{i_t}{i_{t-1}}\right) &= \frac{\kappa}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2
\end{aligned}$$

• The government spending shock evolves according to

$$\ln \nu_{g,t} = \rho_g \ln \nu_{g,t-1} + \sigma_g \varepsilon_{g,t}$$

A2. Steady State

Given the steady state labor hours, the steady state inflation rate and the steady state fiscal policy calibration, the remaining variables are defined by the system:

$$\begin{aligned}
R &= \frac{\bar{\pi}}{\beta} \\
r^k &= \frac{\frac{1}{\beta} - (1-\delta)}{1-\tau^k} \\
a'(1) &= r^k \left(1-\tau^k\right) \\
w &= (1-\alpha)\left[mc\left(\frac{\alpha}{r^k}\right)^{\alpha}\right]^{\frac{1}{1-\alpha}} \\
k &= \frac{\alpha}{1-\alpha}\frac{w\bar{n}}{r^k} \\
i &= \delta k \\
y &= k^{\alpha}\bar{n}^{1-\alpha} \\
c &= y - i - g \\
tr &= \left(1 - \frac{1}{\beta}\right) b + \tau^n w n + \tau^k r^k k - g \\
c^* &= c + \alpha_g g \\
\lambda &= \frac{1}{c^*(1-h)} \\
mc &= \frac{\theta_p - 1}{\theta_p} \\
\varrho &= \frac{w\lambda}{\mathcal{M}^w n^{\eta}} \\
\chi &= \varrho (1-\tau_n)
\end{aligned}$$

A3. Log-Linearized System

Let $\hat{x}_t = \ln(x_t/\bar{x})$ denote the percentage deviation of a variable x_t from its steady-state $\bar{x}$.

• The first order conditions of the household

$$
\begin{aligned}
\hat{\lambda}_t &= -\frac{1}{1-h}\hat{c}_t^* + \frac{h}{1-h}\hat{c}_{t-1}^* \\
\hat{c}_t^* &= \frac{c}{c+\alpha_g g}\hat{c}_t + \frac{\alpha_g g}{c+\alpha_g g}\hat{g}_t \\
\hat{\lambda}_t &= E_t\hat{\lambda}_{t+1} + \hat{R}_t - E_t\hat{\pi}_{t+1} \\
\hat{r}_t^k &= \frac{\zeta_2}{1-\zeta_2}\hat{u}_t \\
\hat{q}_t &= E_t\hat{\lambda}_{t+1} - \hat{\lambda}_t + \beta(1-\delta)E_t\hat{q}_{t+1} + \beta\left(1-\tau^k\right)r^k E_t\hat{r}_{t+1}^k \\
0 &= E_t\hat{i}_{t+1} - (1+\beta)\hat{i}_t + \frac{1}{\kappa}\hat{q}_t + \hat{i}_{t-1} \\
\hat{\Omega}_t &= \omega_w\beta\hat{\Omega}_{t+1} - \omega_w\beta(1-\theta_w)\hat{w}_{t+1} - \omega_w\beta(1-\theta_w)\hat{\pi}_{t+1} - \omega_w\beta(1-\theta_w)\hat{\pi}_{w,t+1}^* \\
&\quad + (1-\omega_w\beta\theta_w)\hat{w}_t + \omega_w\beta(1-\theta_w)\iota_w\hat{\pi}_t + (1-\theta_w)\hat{\pi}_{w,t}^* - (1-\omega_w\beta)\left(\hat{\lambda}_t + \hat{n}_t\right) \\
\hat{\Omega}_t &= \omega_w\beta\hat{\Omega}_{t+1} + \omega_w\beta\theta_w(1+\eta)\hat{w}_{t+1} + \omega_w\beta\theta_w(1+\eta)\hat{\pi}_{t+1} + \omega_w\beta\theta_w(1+\eta)\hat{\pi}_{w,t+1}^* \\
&\quad - \omega_w\beta\theta_w(1+\eta)\hat{w}_t - \omega_w\beta\theta_w(1+\eta)\iota_w\hat{\pi}_t - \theta_w(1+\eta)\hat{\pi}_{w,t}^* + (1-\omega_w\beta)(1+\eta)\hat{n}_t
\end{aligned}
$$

• The wage index evolves as:

$$
0 = \hat{\pi}_{w,t}^* - \frac{\omega_w}{1-\omega_w}\hat{w}_t - \frac{\omega_w}{1-\omega_w}\hat{\pi}_t + \frac{\omega_w}{1-\omega_w}\hat{w}_{t-1} - \frac{\omega_w\iota_w}{1-\omega_w}\hat{\pi}_{t-1}
$$

• The first order conditions of the firm

$$
\begin{aligned}
0 &= \hat{F}_{1,t} - \hat{F}_{2,t} \\
\hat{F}_{1,t} &= \omega_p\beta E_t\hat{F}_{1,t+1} + \omega_p\beta\theta_p E_t\hat{\pi}_{t+1} - \omega_p\beta\theta_p\iota_p\hat{\pi}_t + (1-\omega_p\beta)\left(\hat{\lambda}_t + \hat{mc}_t + \hat{y}_t\right) \\
\hat{F}_{2,t} &= \omega_p\beta E_t\left(\hat{F}_{2,t+1} - \hat{\pi}_{t+1}^*\right) - \omega_p\beta(1-\theta_p)E_t\hat{\pi}_{t+1} + \hat{\pi}_t^* + \omega_p\beta(1-\theta_p)\iota_p\hat{\pi}_t \\
&\quad + (1-\omega_p\beta)\left(\hat{\lambda}_t + \hat{y}_t\right) \\
\hat{w}_t &= \hat{r}_t^k + \hat{u}_t - \hat{n}_t + \hat{k}_{t-1} \\
\hat{mc}_t &= (1-\alpha)\hat{w}_t + \alpha\hat{r}_t^k
\end{aligned}
$$

• The price level evolves:

$$
0 = \hat{\pi}_t^* - \frac{\omega_p}{(1-\omega_p)}\hat{\pi}_t + \frac{\omega_p\iota_p}{(1-\omega_p)}\hat{\pi}_{t-1}
$$

• Monetary authority follow its Taylor rule

$$
\hat{r}_t = (1-\psi_r)\phi_\pi\hat{\pi}_t + (1-\psi_r)\phi_y\hat{y}_t + \psi_r\hat{r}_{t-1}
$$

• Government budget constraint:

$$
\tau^n wn(\hat{w}_t + \hat{n}_t) + \tau^k r^k k\left(\hat{r}_t^k + \hat{u}_t\right) + b\hat{b}_t + \frac{b}{\beta}\hat{\pi}_t - g\hat{g}_t = \frac{b}{\beta}\left(\hat{r}_{t-1} + \hat{b}_{t-1}\right) - \tau^k r^k k\hat{k}_{t-1}
$$

where

$$\hat{g}_t = \psi_g \hat{g}_{t-1} - \gamma_g (1 - \psi_g) \hat{b}_{t-1} + \hat{\nu}_{g,t}$$

• Markets clear:

$$\begin{aligned} y\hat{y}_t &= c\hat{c}_t + i\hat{i}_t + g\hat{g}_t + \left(1 - \tau^k\right) r^k k \hat{u}_t \\ \hat{y}_t &= (1 - \alpha) \hat{n}_t + \alpha \hat{k}_{t-1} + \alpha \hat{u}_t - \hat{\xi}_{p,t} \end{aligned}$$

where

$$\begin{aligned} \hat{k}_t &= (1 - \delta) \hat{k}_{t-1} + \delta \hat{i}_t \\ \hat{\xi}_{p,t} &= \omega_p \theta_p \hat{\pi}_t - (1 - \omega_p) \theta_p \hat{\pi}_t^* - \omega_p \theta_p \iota_p \hat{\pi}_{t-1} + \omega_p \hat{\xi}_{p,t-1} \end{aligned}$$

• The government spending shock evolves according to

$$\hat{\nu}_{g,t} = \rho_g \hat{\nu}_{g,t-1} + \sigma_g \varepsilon_{g,t}$$

Appendix B

This appendix lists the equilibrium conditions, steady state, and log-linearized system used for the simulation in chapter 2.

B1. Equilibrium Conditions

• The first order conditions of the household

$$
\begin{aligned}
\lambda_t &= \frac{1}{c_t^* - h c_{a,t-1}^*} \\
c_t^* &= c_t + \alpha_g y_t^g \\
{R_t}^{-1} &= \beta E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \frac{1}{\pi_{t+1}} \right) \\
a'(\mu_t) &= \left(1 - \tau^k\right) r_t^k \\
q_t &= \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \left[\left(1 - \tau^k\right) \mu_{t+1} r_{t+1}^k - a(\mu_{t+1}) + q_{t+1}(1 - \delta) \right] \right\} \\
1 &= q_t \left[1 - S\left(\frac{i_t}{i_{t-1}} \right) - S'\left(\frac{i_t}{i_{t-1}} \right) \frac{i_t}{i_{t-1}} \right] + \beta E_t q_{t+1} \frac{\lambda_{t+1}}{\lambda_t} S'\left(\frac{i_{t+1}}{i_t} \right) \left(\frac{i_{t+1}}{i_t} \right)^2 \\
k_t &= (1 - \delta) k_{t-1} + \left[1 - S\left(\frac{i_t}{i_{t-1}} \right) \right] i_t
\end{aligned}
$$

• The first order conditions of the firm

$$
\begin{aligned}
0 &= (1 - \theta_p) F_{2,t} + \theta_p F_{1,t} \\
F_{1,t} &= \lambda_t mc_t y_t^p + \omega_p \beta E_t \left(\frac{\pi_t^{\iota_p} \pi^{1-\iota_p}}{\pi_{t+1}} \right)^{-\theta_p} F_{1,t+1} \\
F_{2,t} &= \lambda_t \pi_t^* y_t^p + \omega_p \beta E_t \left(\frac{\pi_t^{\iota_p} \pi^{1-\iota_p}}{\pi_{t+1}} \right)^{1-\theta_p} \left(\frac{\pi_t^*}{\pi_{t+1}^*} \right) F_{2,t+1} \\
1 &= (1 - \omega_p)(\pi_t^*)^{1-\theta_p} + \omega_p \left(\frac{\pi_{t-1}^{\iota_p} \pi^{1-\iota_p}}{\pi_t} \right)^{1-\theta_p} \\
\frac{w_t}{r_t^k} &= \frac{1-\alpha}{\alpha} \frac{\mu_t k_{t-1}}{n_t^p} \\
mc_t &= \alpha^{-\alpha} (1 - \alpha)^{\alpha - 1} w_t^{1-\alpha} \left(r_t^k\right)^\alpha
\end{aligned}
$$

• The first order conditions of the labor market

$$
\begin{aligned}
\Omega_t &= \lambda_t w_t n_t \left(\pi^*_{w,t}\right)^{1-\theta_w} + \omega_w \beta E_t \left(\frac{\pi_t^{\iota_w}\pi^{1-\iota_w}}{\pi_{t+1}}\right)^{1-\theta_w} \left(\frac{\pi^*_{w,t+1}}{\pi^*_{w,t}}\frac{w_{t+1}}{w_t}\right)^{\theta_w-1} \Omega_{t+1} \\
\Omega_t &= \mathcal{M}^w \varrho \left(\pi^*_{w,t}\right)^{-\theta_w(1+\eta)} n_t^{1+\eta} + \omega_w \beta E_t \left(\frac{\pi_t^{\iota_w}\pi^{1-\iota_w}}{\pi_{t+1}}\right)^{-\theta_w(1+\eta)} \left(\frac{\pi^*_{w,t+1}}{\pi^*_{w,t}}\frac{w_{t+1}}{w_t}\right)^{\theta_w(1+\eta)} \Omega_{t+1} \\
1 &= (1-\omega_w)\left(\pi^*_{w,t}\right)^{1-\theta_w} + \omega_w \left(\frac{\pi_{t-1}^{\iota_w}\pi^{1-\iota_w}}{\pi_t}\frac{w_{t-1}}{w_t}\right)^{1-\theta_w} \\
w_t &= \varrho \left(c_t^* - h c_{t-1}^*\right) l_t^{\eta}
\end{aligned}
$$

• Monetary authority follow its Taylor rule:

$$
R_t = (R_{t-1})^{\varphi_r} \left[R\left(\frac{\pi_t}{\pi}\right)^{\phi_\pi} \left(\frac{y_t}{\bar{y}}\right)^{\phi_y}\right]^{1-\varphi_r}
$$

• Government budget constraint:

$$
g_t + w_t n_t^g + tr + \frac{R_{t-1}b_{t-1}}{\pi_t} = \tau^n w_t n_t + \tau^k r_t^k \mu_t k_{t-1} + b_t + y_t^g
$$

where

$$
\begin{aligned}
g_t &= g_{t-1}^{\psi_g}\left[\bar{g}\left(b_{t-1}/\bar{b}\right)^{-\gamma_g}\right]^{1-\psi_g} \\
n_t^g &= \left(n_{t-1}^g\right)^{\psi_{ng}}\left[\bar{n^g}\left(b_{t-1}/\bar{b}\right)^{-\gamma_{ng}}\right]^{1-\psi_{ng}} \nu_{n^g,t} \\
\ln \nu_{n^g,t} &= \rho_{n^g} \ln \nu_{n^g,t-1} + \sigma_{n^g}\varepsilon_{n^g,t}, \varepsilon_{n^g,t} \sim \mathbb{N}(0,1)
\end{aligned}
$$

• Markets clear:

$$
\begin{aligned}
y_t &= c_t + i_t + g_t + w_t n_t^g + a(\mu_t) k_{t-1} \\
y_t &= y_t^p + y_t^g \\
y_t^p &= \frac{\left(n_t^p\right)^{1-\alpha}\left(k_t^s\right)^{\alpha}}{\xi_{p,t}} \\
y_t^g &= \left(n_t^g\right)^{\gamma} g_t^{1-\gamma} \\
n_t &= n_t^p + n_t^g
\end{aligned}
$$

where

$$
\xi_{p,t} = \omega_p \left(\frac{\pi_{t-1}^{\iota_p}\pi^{1-\iota_p}}{\pi_t}\right)^{-\theta_p} \xi_{p,t-1} + (1-\omega_p)\left(\pi_t^*\right)^{-\theta_p}
$$

B2. Steady State

Given the steady state labor hours, the steady state inflation rate and the steady state fiscal policy calibration, the remaining variables are defined by the system:

$$
\begin{aligned}
\mathcal{M}^p &= \frac{\theta_p}{\theta_p - 1} \\
\mathcal{M}^w &= \frac{\theta_w}{\theta_w - 1} \\
R &= \frac{\pi}{\beta} \\
r^k &= \frac{\frac{1}{\beta} - (1-\delta)}{1-\tau^k} \\
a'(1) &= r^k\left(1-\tau^k\right) \\
w &= (1-\alpha)\left[mc\left(\frac{\alpha}{r^k}\right)^{\alpha}\right]^{\frac{1}{1-\alpha}} \\
n^p &= n\left(1-\frac{n^g}{n}\right) \\
n^g &= n - n^p \\
k &= \frac{\alpha}{1-\alpha}\frac{wn^p}{r^k} \\
i &= \delta k \\
y^p &= \left(n^p\right)^{1-\alpha}k^{\alpha} \\
y^g &= \left(n^g\right)^{\gamma}g^{1-\gamma} \\
y &= y^p + y^g \\
c &= y - i - g - wn^g \\
tr &= \left(1-\frac{1}{\beta}\right)b + \tau^n wn + \tau^k r^k k + y^g - wn^g - g \\
c^* &= c + \alpha_g y^g \\
\lambda &= \frac{1}{c^*(1-h)} \\
mc &= \frac{\theta_p - 1}{\theta_p} \\
\varrho &= \frac{w\lambda}{\mathcal{M}^w n^{\eta}} \\
\chi &= \varrho\left(1-\tau_n\right) \\
l &= \left(\frac{w\lambda}{\varrho}\right)^{\frac{1}{\eta}}
\end{aligned}
$$

B3. Log-Linearized System

Let $\hat{x}_t = \ln(x_t/\bar{x})$ denote the percentage deviation of a variable x_t from its steady-state $\bar{x}$.

• The first order conditions of the household

$$
\begin{aligned}
\frac{1}{1-h}\hat{c}_t^* + \hat{\lambda}_t - \frac{h}{1-h}\hat{c}_{t-1}^* &= 0 \\
\hat{c}_t^* - \frac{c}{c^*}\hat{c}_t - \frac{\alpha_g y^g}{c^*}\hat{y}_t^g &= 0 \\
E_t\hat{\lambda}_{t+1} - E_t\hat{\pi}_{t+1} - \hat{\lambda}_t + \hat{R}_t &= 0 \\
\frac{\zeta_2}{1-\zeta_2}\hat{\mu}_t - \hat{r}_t^k &= 0 \\
E_t\hat{\lambda}_{t+1} + \beta\left(1-\tau^k\right) r^k E_t\hat{r}_{t+1}^k + \beta(1-\delta)E_t\hat{q}_{t+1} - \hat{\lambda}_t - \hat{q}_t &= 0 \\
\beta E_t\hat{i}_{t+1} - (1+\beta)\hat{i}_t + \frac{1}{\kappa}\hat{q}_t + \hat{i}_{t-1} &= 0 \\
\hat{k}_t - \delta\hat{i}_t - (1-\delta)\hat{k}_{t-1} &= 0
\end{aligned}
$$

• The first order conditions of the firm

$$
\begin{aligned}
\hat{F}_{1,t} - \hat{F}_{2,t} &= 0 \\
\omega_p\beta E_t\hat{F}_{1,t+1} + \omega_p\beta\theta_p E_t\hat{\pi}_{t+1} - \omega_p\beta\theta_p\iota_p\hat{\pi}_t + (1-\omega_p\beta)\left(\hat{\lambda}_t + \hat{mc}_t + \hat{y}_t\right) - \hat{F}_{1,t} &= 0 \\
\omega_p\beta E_t\left(\hat{F}_{2,t+1} - \hat{\pi}_{t+1}^*\right) + \hat{\pi}_t^* - \omega_p\beta(1-\theta_p)E_t\hat{\pi}_{t+1} & \\
+\omega_p\beta(1-\theta_p)\iota_p\hat{\pi}_t + (1-\omega_p\beta)\left(\hat{\lambda}_t + \hat{y}_t\right) - \hat{F}_{2,t} &= 0 \\
\hat{\pi}_t^* - \frac{\omega_p}{(1-\omega_p)}\hat{\pi}_t + \frac{\omega_p\iota_p}{(1-\omega_p)}\hat{\pi}_{t-1} &= 0 \\
\hat{w}_t - \hat{r}_t^k - \hat{\mu}_t + \hat{n}_t^p - \hat{k}_{t-1} &= 0 \\
\hat{mc}_t - (1-\alpha)\hat{w}_t - \alpha\hat{r}_t^k &= 0
\end{aligned}
$$

• The first order conditions of the labor market

$$
\begin{aligned}
\omega_w\beta\hat{\Omega}_{t+1} - \omega_w\beta(1-\theta_w)\hat{w}_{t+1} + (1-\omega_w\beta\theta_w)\hat{w}_t & \\
-\omega_w\beta(1-\theta_w)\hat{\pi}_{t+1} + \omega_w\beta(1-\theta_w)\iota_w\hat{\pi}_t & \\
-\omega_w\beta(1-\theta_w)\hat{\pi}_{w,t+1}^* + (1-\theta_w)\hat{\pi}_{w,t}^* + (1-\omega_w\beta)\left(\hat{\lambda}_t + \hat{n}_t\right) - \hat{\Omega}_t &= 0 \\
\omega_w\beta\hat{\Omega}_{t+1} + \omega_w\beta\theta_w(1+\eta)\hat{w}_{t+1} - \omega_w\beta\theta_w(1+\eta)\hat{w}_t & \\
+\omega_w\beta\theta_w(1+\eta)\hat{\pi}_{t+1} - \omega_w\beta\theta_w(1+\eta)\iota_w\hat{\pi}_t & \\
+\omega_w\beta\theta_w(1+\eta)\hat{\pi}_{w,t+1}^* - \theta_w(1+\eta)\hat{\pi}_{w,t}^* + (1-\omega_w\beta)(1+\eta)\hat{n}_t - \hat{\Omega}_t &= 0 \\
\hat{\pi}_{w,t}^* - \frac{\omega_w}{1-\omega_w}\hat{w}_t - \frac{\omega_w}{1-\omega_w}\hat{\pi}_t + \frac{\omega_w}{1-\omega_w}\hat{w}_{t-1} - \frac{\omega_w\iota_w}{1-\omega_w}\hat{\pi}_{t-1} &= 0 \\
\hat{c}_t^* - h\hat{c}_{t-1}^* + \eta\hat{l}_t - (1-h)\hat{w}_t &= 0
\end{aligned}
$$

• The unemployment rate $\hat{u}_t$:

$$
\hat{u}_t = \hat{l}_t - \hat{n}_t
$$

• Monetary authority follow its Taylor rule

$$\hat{R}_t - (1-\psi_r)\,\phi_\pi \hat{\pi}_t - (1-\psi_r)\,\phi_y \hat{y}_t \;\;=\;\; \psi_r \hat{R}_{t-1}$$

• Government budget constraint:

$$g\hat{g}_t + wn^g \hat{n}_t^g + (wn^g - \tau^n wn)\,\hat{w}_t + \frac{b}{\beta}\left(\hat{R}_{t-1} + \hat{b}_{t-1} - \hat{\pi}_t\right) =$$
$$\tau^n wn\hat{n}_t + \tau^k r^k k\left(\hat{r}_t^k + \hat{\mu}_t + \hat{k}_{t-1}\right) + b\hat{b}_t + y^g \hat{y}_t^g$$

where

$$\begin{aligned}
\hat{g}_t &= \psi_g \hat{g}_{t-1} - \gamma_g (1-\psi_g)\,\hat{b}_{t-1} \\
\hat{n}_t^g - \hat{\nu}_{n^g,t} &= \psi_{n^g} \hat{n}_{t-1}^g - \gamma_{n^g} (1-\psi_{n^g})\,\hat{b}_{t-1} \\
\hat{\nu}_{n^g,t} &= \rho_{n^g} \hat{\nu}_{n^g,t-1} + \sigma_{n^g} \varepsilon_{n^g,t}
\end{aligned}$$

• Markets clear:

$$\begin{aligned}
y\hat{y}_t - c\hat{c}_t - i\hat{i}_t - g\hat{g}_t - wn^g\left(\hat{w}_t + \hat{n}_t^g\right) - \left(1-\tau^k\right) r^k k\hat{\mu}_t &= 0 \\
y\hat{y}_t - y^p \hat{y}_t^p - y^g \hat{y}_t^g - &= 0 \\
\hat{y}_t^p + \hat{\xi}_{p,t} - \alpha\hat{\mu}_t - (1-\alpha)\,\hat{n}_t^p &= \alpha\hat{k}_{t-1} \\
\hat{y}_t^g - \gamma\hat{n}_t^g - (1-\gamma)\,\hat{g}_t &= 0 \\
\hat{n}_t - \frac{n^p}{n}\hat{n}_t^p - \frac{n^g}{n}\hat{n}_t^g &= 0
\end{aligned}$$

where

$$\hat{\xi}_{p,t} - \omega_p \theta_p \hat{\pi}_t + (1-\omega_p)\,\theta_p \hat{\pi}_t^* \;\;=\;\; \omega_p \hat{\xi}_{p,t-1} - \omega_p \theta_p \iota_p \hat{\pi}_{t-1}$$