DISSERTATION

ESSAYS ON THE DYNAMIC EFFECTS OF FISCAL POLICY ON OUTPUT AND UNEMPLOYMENT IN THE PRESENCE OF LABOR MARKET FRICTIONS AND LABOR MOBILITY BARRIERS: THEORETICAL INVESTIGATIONS AND EMPIRICAL STUDIES

XIANGCAI MENG

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National Graduate Institute For Policy Studies

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DEDICATION

To my parents

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ABSTRACT

ESSAYS ON THE DYNAMIC EFFECTS OF FISCAL POLICY ON OUTPUT AND UNEMPLOYMENT IN THE PRESENCE OF LABOR MARKET FRICTIONS AND LABOR MOBILITY BARRIERS: THEORETICAL INVESTIGATIONS AND EMPIRICAL STUDIES

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In any economy, government intervention is almost inevitable because of market failures and market imperfections. From the macroeconomic perspective, government could intervene in the economy through either supply side policies, or demand side policies, or both. How does government intervention affect the aggregate economy?

To improve our understanding about the characters of different categories of government interventions in macroeconomics, this dissertation attempts to assess the impacts of both the supply side intervention policies, such as labor market regulations, and demand side intervention policies, such as fiscal policies, on the aggregate economy. In particular, this dissertation concentrates on investigating the impacts of the demand aspect fiscal policies, and the supply aspect labor market regulations, on output and unemployment.

More concretely, this dissertation seeks to rigorously study three important questions associated with evaluating the impacts of different categories of government interventions on aggregate output and the labor market. First, which category of the different government spending components, i.e., government wage, consumption, and investment, is

more effective in boosting output and reducing unemployment? Second, how do changes in different government spending components and diverse categories of taxes affect the labor market dynamics during recessions? Third, what are the effects of changing fiscal policies and labor market regulations simultaneously on the aggregate economy? To properly examine these three questions, we employ three different theoretical frameworks and distinctive economies, which are appropriate to investigate each question under consideration, in different chapters of this thesis.

This dissertation consists of six Chapters. Chapter 1 is an introduction to the whole thesis. Chapter 2 reviews the related literature and briefly articulates the contributions of this dissertation.

Chapter 3 investigates the first important question: Which component of government wage expenditure, government investment, and government consumption is more effective in stimulating the economy? Through estimating a structural vector autoregressive model using the U.S. data, we find that government wage expenditure is the more effective component in boosting output and reducing unemployment, according to the estimated cumulative output and unemployment multipliers.

To understand why government wage expenditure is the more effective component, we develop a directed search model with heterogeneous government expenditures, a productive government sector, and complementarities between government goods and private goods in consumption. Calibrating the model to the U.S. economy, we show that the model can generate the empirical pattern of the dynamic responses of output and unemployment to government spending shocks of each component, as well as the order of the cumulative output and unemployment rate multipliers. Moreover, the model demonstrates that the mechanisms though which different government spending components affect the economy are not the same, in particular, government wage expenditure is more effective than the other components because it affects the labor market both directly via the employment in the public sector, and indirectly by the induced demand for labor.

In addition, we also evaluate the quantitative effectiveness increments from reallocating government expenditures through counterfactual experiments. We find that raising government wage expenditure financed by lowering government consumption expenditure generates the largest cumulative output and unemployment rate multipliers: 20 percent increase of government wage expenditure raises the cumulative output multiplier by 5.25 percent and reduces the cumulative unemployment rate multiplier by 8.22 percent, respectively. This analysis suggests that reallocation of government resources can be an alternative to alleviate the rising government deficit.

Chapter 4 studies the second important question: How do changes in different government spending components and various categories of taxes affect the labor market dynamics during recessions? This problem is investigated through employing the episode of the 1990s in Japan, which is labeled as the Lost Decade. During the 1990s, the unemployment rate surged from 2.08% in 1990 to 5.40% in 2002, while the job finding probability decreased from 42% to 27%, and the probability of losing a job increased from 0.80% to 1.87%. Meanwhile, the Japanese government changed their fiscal policies to boost the economy and to cushion its labor market in the 1990s. From the spending aspect, the share of aggregate government spending in gross national product (GNP) was increased by more than 20% from 1990 to 2002, where the respective share of government wage, consumption, and investment in GNP changed differently during the 1990s. From the tax aspect, the consumption tax was raised from 0.03 to 0.05 in 1997, while the labor tax and capital tax were fairly stable according to Mendoza et al. (1994) and Esteban-Pretel et al. (2010).

To evaluate the impacts of these different changes in fiscal policy instruments on the unemployment rate in Japan during the 1990s, we build, calibrate, and simulate a dynamic general equilibrium model with search and matching frictions in the labor market, a productive government sector, heterogenous government spending components, and different categories of taxes. The model is calibrated to match the data moment of the Japanese economy in 1990, through employing the solution method of a two-boundary problem, we solve and simulate the transition path of the economy from the initial steady state to a new steady state far away in the future.

With the calibrated model, we evaluate the potential impacts of the changes in different categories of fiscal policies on unemployment during the Lost Decade through counterfactual experiments. We find that if government investment and wage didn't change, the unemployment rate in 2002 would be 7.56% and 0.36% lower, respectively, while it would be 5.90% higher if government consumption did not change. As the wealth effect increases the value of employment and decreases the value of unemployment, leading to rising matching surplus, which encourages hiring and reduces unemployment. Meanwhile, 10% tax reductions in labor, capital, and consumption after 1990 reduces the unemployment rate in 2002 by 15.87%, 9.59%, and 13.83% respectively. Their effects are not the same because different categories of taxes affect the economy heterogeneously: labor tax directly influences the value of employed workers, capital tax affects the accumulation of capital and hence the value of vacancy posting, while consumption tax affects the wealth of the household. Our study confirms that countercyclical fiscal policies contribute to cushion the labor market during recessions.

Chapter 5 examines the third important question: What are the effects of changing fiscal policies and labor market policies simultaneously on the aggregate economy? This problem is motivated by the episode of the Chinese economy since the late 1970s, which is a period of fast economic growth accompanied by enlarging urban-rural income inequality. This period is also featured by the existence and changes of labor mobility barriers across regions, which is the supply side intervention, and the urban-biased allocation of government education spending, which is the demand side intervention. The labor mobility barriers and urban-biased government education expenditures have been considered as two main determinants of the enlarging interregional income inequality.

To investigate how these two factors affect the urban-rural income inequality theoretically, we develop a two-region growth model, where labor mobility barriers affect the cost of migration across regions, while government education expenditures influence the accumulation of regional human capital. Under several tractability assumptions, we characterize the equilibrium paths of regional mean incomes, with which we evaluate the impacts of reducing labor mobility barriers and reallocating government education spending on interregional income inequality, which is measured by the ratio of urban to rural mean incomes, through comparative dynamics analysis.

We find that reallocating government education spending more equally mitigates the interregional income inequality as this reallocation reduces the urban mean income and raises the rural mean income simultaneously. While only reducing the labor mobility barriers does not necessarily decrease the urban-rural income inequality because it generates counteracting effects on the mean income of the rural stayers and that of the rural migrants. The combination of these two policies is likely to reduce the interregional income inequalities if the effect from reallocating government resources dominates. Our theoretical investigation suggests that reallocating government education resources more equally across regions could be very important in mitigating the enlarging urban-rural income inequality.

Chapter 6 summarizes the main findings of this dissertation. It also outlines the policy implications and discusses the directions for further studies.

Our analysis in this dissertation implies that different categories of government intervention policies generate heterogenous impacts on the aggregate output and the labor market. Moreover, different changes in distinctive policy instruments might exert counteracting effects on the aggregate economy. Therefore, elaborate considerations about the potential impacts of different policy instruments are indispensable in the process of policy recommendation and policy implementation.

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Chapter 1

Introduction

In this chapter, we first highlight the motivation of the studies in this dissertation. And then, we articulate the broad research objective as well as the concrete study targets. After that, we discuss the background of the economies under consideration for each specific research question. Finally, we briefly talk about the methodologies employed in this dissertation, and the organization of this dissertation.

1.1 Motivation

In any economy, government intervention is almost indispensable due to market failures and market imperfections. From the macroeconomic perspective, government could intervene in the economy through either supply side policies, such as labor market regulations and industrial policies, or demand side policies, such as fiscal policies and monetary policies, or both supply side and demand side policies. How do these government interventions influence the aggregate economy?

To better understand the characters of government interventions in macroeconomics, a complete assessment of the impacts of different categories of supply side policies and demand side policies, through which government interventions affect the economy, on the macroeconomic variables, specifically, output and unemployment, is essential and very important. Because this assessment not only helps to shed light on how distinctive government interventions affect the aggregate economy differently, but also assists in providing evidence on the effectiveness of distinctive categories of government interventions, both of which would contribute to improve the design of government intervention policies. This dissertation concentrates on the demand aspect fiscal policy, and the supply aspect labor market regulations.

The impacts of demand side policies, in particular, monetary policies, on the macroeconomic variables have been intensively examined both empirically and theoretically, while relatively fewer attention has been devoted to investigating the impacts of fiscal policies in the past two decades (Krugman, 2009; Blanchard et al., 2010; and Gomes, 2010). Because the conventional wisdom believes that monetary policy is adequate enough to meet the requirement of managing the aggregate demand (Gomes, 2010), thus Blanchard et al. (2010) stated, "......, fiscal policy took a backseat to monetary policy."

However, the strong response of fiscal policy during the "Great Recession"[1], and the reignited research interest in fiscal policy, demonstrate that our current understanding of

[1] The "Great Recession" indicates the general economic recession experienced by many economies at the end of the first decade in 2000s, the magnitudes and timing of the economic decline vary with countries.

this conventional policy instrument could be quite limited (Poterba, 2011). Since on the one hand, there is no consensus on the magnitudes of the stimulative effects of increasing government spending and reducing taxes on aggregate economy. On the other hand, while there was a widespread agreement that different categories of government spending and various types of taxes would generate heterogenous effects on the aggregate economy, but the refined estimates and theoretical explanations are quite limited (Gomes, 2010; Poterba, 2011; and Rogoff, 2011).

The effects of supply side policies, in particular, labor market regulations, of government intervention on the aggregate economy have been evaluated mostly for developed economies, such as Siebert (1997), Nickell and Layard (1999), Belot and Van Ours (2001), Layard et al. (2005), Kahn (2012), Krebs and Scheffel (2013), and Blanchard et al. (2014). Relatively fewer studies examined the dynamic impacts of government interventions from the supply side, especially the labor market regulations, for developing economies, Cai et al. (2008), Guner et al. (2008), and Satchi and Temple (2009) are some of these limited studies.

Moreover, out of these existing limited studies, even fewer had ever examined the potential impacts of government interventions from both supply side and demand side for developing economies, which is a serious omission in the literature. Because on the one hand, governments, in particular, those in developing economies seldom only employ supply side policies or only employ demand side policies, examining the government intervention from both demand side and supply side helps to understand how these interventions affect the aggregate economy in developing countries. On the other hand, evaluating the impacts of government intervention from both supply and demand side can demonstrate how their interactions influence the macroeconomic economy, which is very helpful for the designing of government policies in developing economies.

Therefore, to completely assess the impacts of different categories of government interventions on the aggregate economy, in particular, output and unemployment, further studies should be directed to investigate the dynamic effects of fiscal policy, especially, the effects of different categories of government spending and various classes of taxes, as well as both the supply side and demand side policies simultaneously in developing economies on the aggregate economy. Both of which would not only improve our understanding about the characters of different categories of government interventions on the aggregate economy, but also contribute to provide better guidance for policy recommendations.

1.2 Research Objective

Considering the significance of further investigating the dynamic effects of different categories of fiscal policies, i.e., different categories of government spending components and distinctive classes of taxes, as well as the impacts of imposing the fiscal policies and the labor market regulations simultaneously, on the aggregate economy, the general research objective of this dissertation is to completely assess the dynamic effects of different categories of government interventions on aggregate output and the labor market.

In particular, this dissertation attempts to rigorously study three important questions associated with evaluating the impacts of government interventions on aggregate economy. First, which category of the different government spending components, i.e., government wage, government consumption, and government investment, is more effective in stimulating the economy? Second, how do changes in different government spending and various categories of taxes affect the labor market dynamics during recessions? Third, what are the effects of changing fiscal policies and labor market regulations simultaneously on the aggregate economy?

To properly examine these three important questions concerning the dynamic effects of different categories of government interventions on the aggregate economy, different theoretical frameworks and distinctive economies, which are quite appropriate to investigate each question under consideration, are employed in different chapters of our studies.

Through investigating these three important questions, this dissertation attempts to contribute to the existing literature empirically, theoretically, and quantitatively. From the empirical aspect, this thesis tries to employ alternative identification strategies to evaluate the dynamic effects of different government spending shocks on the aggregate economy. From the theoretical perspective, this dissertation attempts to provide insightful understandings about why different government spending components and various categories of taxes might affect the aggregate economy heterogeneously. From the quantitative perspective, this dissertation intends to evaluate the impacts of reallocating different government spending components and examining the effects of fiscal policy changes on unemployment during recessions. In terms of the policy implications, this dissertation attempts to propose several guidelines and some conjectures about simultaneously implementing supply side and demand side policies when conducting government interventions.

1.3 Background

Now we briefly discuss the background of these distinctive economies that were employed to investigate the aforementioned three important questions, and the detailed research objectives for each question, consecutively.

1.3.1 The Heterogenous Government Spending in U. S.

According to the National Income and Product Table (NIPA) in U. S., it has been well recognized that aggregate government spending consists of different components (Gomes, 2010; Burgert and Gomes, 2011; Bermperoglou et al., 2012; Cortuk and Güler; Rogoff, 2011; and Poterba, 2011), such as government wage expenditure (GWE), i.e., compensation of government employees, government consumption expenditure (GCE), i.e., those spent on national defense and public education, and government investment expenditure (GIE), i.e., those devoted to social infrastructure and so on. As claimed by Poterba (2011) and Rogoff (2011), "······, different types of spending would have different effects, ······, there was a limited base of research available to refine estimates of these policy impacts". Moreover, Reis (2011) argued that the mechanisms through which government spending stimulates the economy have not been well characterized[2].

Therefore, our first objective is to identify which government spending component is more effective in stimulating the economy, i.e., simultaneously boosting output and reducing unemployment, and to explain why it is more effective than the other components. Through this specific objective, we attempt to contribute to the literature from three aspects: First, empirically, we want to provide refined estimates for the effects of different government spending components on output and unemployment through employing the disaggregated U.S. data, so as to mitigate the gap mentioned by Poterba (2011) and Rogoff (2011). Second, theoretically, we seek to elaborately highlight the characters of different government spending components in the economy, so as to better characterize the mechanisms via which different government expenditures stimulate the economy, such that we can deal with the concern of Reis (2011). Third, quantitatively, we make an endeavor to evaluate the potential effectiveness increments, in terms of changes in the cumulative output multipliers and the cumulative unemployment multipliers[3], from reallocating government spending from the less effective component to the more effective component, which is more interested by economists and policy makers.

1.3.2 The Changes of Fiscal Policies During The 1990s in Japan

In the literature, the 1990s in Japan is labeled as the Lost Decade (Hayashi and Prescott, 2002 and Esteban-Pretel et al., 2010). The unemployment rate surged from 2.08% in 1990 to 5.40% in 2002. Meanwhile, the job finding probability decreased from 42% to 27% and the probability of losing a job increased from 0.80% to 1.87%, during the Lost Decade.

[2]Reis (2011) highlighted that "$\cdots\cdots$, the mechanism by which government policy stimulates the economy in standard models is a caricature of reality at best, $\cdots\cdots$".

[3]The cumulative output multiplier and cumulative unemployment multiplier are defined as the cumulative responses of output and unemployment rate to government spending shocks of each component within two years, following Spilimbergo et al. (2009) and Chinn (2013).

To deal with the deteriorating experiences in the labor market, the Japanese government changed their fiscal policies to boost the economy and to cushion its labor market in the 1990s. From the aspect of government expenditures, the share of aggregate government spending in gross national product (GNP) increases by more than 20% from 1990 to 2002. Underlying this aggregate increase, different spending components changes heterogeneously. The share of government wage expenditure in GNP rises from 6.18% to 6.65%, the share of government consumption in GNP increases from 7.71% to 11.10%, and the share of government investment in GNP actually reduces from 6.35% to 6.32%, respectively, from 1990 to 2002. From the perspective of taxes, the Japanese government raised the proportional consumption tax from 0.03 to 0.05 in 1997. Meanwhile, according to Mendoza et al. (1994) and Esteban-Pretel et al. (2010), the proportional labor income tax rate was fairly stable in the 1990s, and the changes in proportional capital income tax was also very small over the Lost Decade.

The experience of Japan during the 1990s provides an ideal laboratory to thoroughly evaluate the impacts of fiscal policy changes on labor market dynamics, both from the expenditure side and from the tax aspect. However, no existing study ever examined this question in the literature. Thus, our second objective is to evaluate the impacts of changes in different categories of fiscal policies on labor market variables, in particular, the unemployment rate, during the Lost Decade in Japan. Through this specific objective, we attempt to contribute to the literature from two aspects: First, theoretically, we attempt to construct a framework with rich specifications of fiscal policies, which could be employed to conduct quantitative evaluations of different categories of taxes and spending. Second, quantitatively, we want to investigate the impacts of changes in different classes of fiscal policies on labor market dynamics in Japan, which would fill the omission in the literature and will provide evidence for the characters of fiscal policies in economies during recessions.

1.3.3 The Labor Mobility Barriers and Government Education Expenditures in China

During China's rapid economic growth episode since the late 1970s[4], the Gini coefficient, a measure of overall income inequality, has increased from 0.16 in 1978 to 0.48 in 2008 (e.g., Zhu and Wan, 2012 and He, 2012). Moreover, the urban-rural income inequality, captured by the ratio of urban mean income to rural mean income, has also increased from 1.82 in 1983 to 3.31 in 2008.

In the literature, two factors have been widely considered as the main determinants of this enlarging interregional income inequality. On the one hand, the labor mobility barriers, generated by *hukou* system, have been widely considered as one of the main sources of interregional income inequality (e.g., Cai et al., 2002; Liu, 2005; Whalley and Zhang, 2007; and Fu, 2013), as it distorted the allocation of labors and hence the regional income. On the other, the allocation of government education spending across regions has also been considered as an important factor in affecting the interregional income inequalities (e.g., Treiman, 2012; Wu, 2011; Wang et al., 2011; Chen et al., 2010; and Zhu and Ma, 2009), since it directly affects the quality and level of regional education[5].

However, as far as we know, the potential impacts of removing labor mobility barriers and redistributing government education expenditures across regions more equally, on the interregional income inequality have not been rigorously investigated neither theoretically nor quantitatively in the current literature. Therefore, our third objective is to to construct a theoretical framework which could be employed to evaluate the impacts of simultaneously changing labor mobility barriers and reallocating government education resources on the interregional income inequality, and qualitatively examine these impacts with the new framework. Through this concrete objective, we want to contribute to the

[4]In this period, the growth rate of real gross domestic product (GDP) per capita in China has been around 9% per year (e.g., Lin, 2012 and NBS, 2011), where NBS indicates the national bureau of statistics in China.

[5]From 1978 to 2008, the government education expenditure per urban student had been almost twice as much as that per rural student.

literature mainly from two aspects. First, we would construct a framework within which the impacts of government education expenditure, labor mobility barrier, and their interaction on urban-rural income inequality could be examined. Second, we qualitatively characterize how changes in government spending policies and labor market policies as well as their interaction affect the interregional income inequality in China by employing comparative dynamics studies within the new framework.

1.4 Methodology

To examine the impacts of government interventions on the aggregate economy, from the perspective of theoretical models, this dissertation mainly employs and extends two categories of frameworks in contemporary macroeconomic analysis.

On the one hand, to evaluate the government intervention from the demand side, in particular, the dynamic effects of fiscal policy on aggregate economy, this dissertation employs the dynamic stochastic as well as dynamic deterministic general equilibrium framework with search and matching frictions in the labor market à la Mortensen and Pissarides (1994). However, to elaborately investigate the characters of different categories of government spending and various classes of taxes, the standard dynamic stochastic or deterministic general equilibrium model with search and matching frictions is extended with a rich specification of the government sector, as well as the interactions between the public sector and the private sector in our analysis.

On the other hand, to investigate the government intervention from the supply side, in particular, how changes in the labor mobility barriers and reallocation of government education resources affect the urban-rural income inequality in economies like China, this dissertation employs the standard growth model where both physical capital and human capital are incorporated. To appropriately answer the question under consideration, the standard model is extended with two regions, where migration cost is introduced and it is affected by the degree of labor mobility restrictions. In addition, human capital accumulation not only depends on private education input, but also relies on government education spending, as well as the human capital level of their parents, which is employed to capture the intergenerational transmission of human capital.

From the perspective of empirical techniques, this dissertation employs the standard econometric models in modern macroeconomic analysis, following Blanchard and Perotti (2002), Perotti (2005), Galí et al. (2007), Ilzetzki et al. (2013), Tagkalakis (2013), Burgert and Gomes (2011), Monacelli et al. (2010), and Bruckner and Pappa (2012), the structural vector autoregressive model is employed to evaluate the dynamic effects of different categories of government spending on output and unemployment.

From the perspective of simulation methods, this dissertation utilizes two categories of simulation techniques: deterministic simulation and stochastic simulation. Stochastic simulation is employed to investigate how different categories of government spending shocks affect the aggregate economy in the extended dynamic stochastic general equilibrium model with search and matching frictions, productive government sector, and complementarity between private goods and public goods. Deterministic simulation is adopted to examine the dynamic effects of changes in various categories of government spending components and taxes on the unemployment rate and other labor market variables in the extended dynamic general equilibrium model with search and matching frictions in the labor market and rich specifications of fiscal policies.

Therefore, from the perspective of methodology, this dissertation employs standard econometric methods, state of the art macroeconomic theoretical models, and advanced simulation techniques. In addition, both qualitative characterizations and quantitative investigations were conducted in this dissertation.

1.5 Organization

This dissertation is organized as follows. Chapter 2 briefly reviews the literature from a more broader perspective and articulates the contributions of this dissertation. Chapter 3 evaluates the dynamic impacts of heterogenous government spending on output and unemployment, employing a directed search model with a productive government sector and complementarity between private goods and public goods. Chapter 4 investigates how the changes of different fiscal policies affect the unemployment rate during the Lost Decade in Japan, which is a typical episode of economic recession. Both Chapter 3 and Chapter 4 investigates the impacts of government intervention from the demand side policies. Chapter 5 theoretically examines the impacts of removing labor mobility barriers and reallocating government education resources on the urban-rural income inequality in economies like China within the framework of a two region growth model. Chapter 5 examines the impacts of both the supply side and demand side government intervention policies on the aggregate economy. Chapter 6 summarizes and discusses the further research directions and topics.

Chapter 2

Literature Review

In this chapter, we first briefly review the general literature on examining the impacts of government interventions on the aggregate economy. After that, we concisely review the literature associated with each specific question consecutively. Finally, we highlight the contributions of each studies in this dissertation, respectively.

2.1 Overview

The general theme of this dissertation is to evaluate the impacts of different categories of government interventions, both the supply side policy and the demand side policy, on the aggregate economy. Where the fundamental demand side policy that we consider is the fiscal policy, and the essential supply side policy that we consider is the labor market regulation. Thus, we start our general literature retrospection from briefly reviewing the existing studies about the fiscal policy and the labor market regulation.

This dissertation concentrates on examining the impacts of fiscal policy from the demand side of government intervention, partially because the effects of monetary policy from the demand side on the aggregate economy have been intensively examined both empirically and theoretically, such as Leeper et al. (1996), Kim (2000), Boivin and Giannoni (2006), Sims and Zha (2006), Peiris and Saxegaard (2007), Zhang (2009), Christiano et al. (2010), Adolfson et al. (2011), Gertler and Karadi (2011), Barsky et al. (2014), Davig and Doh (2014), Bruno and Shin (2015), and Cúrdia et al. (2015), among many others.

Meanwhile, as noted by Krugman 2009, Blanchard et al. (2010), and Gomes (2010), quite a few studies had ever investigated the impacts of fiscal policies on the aggregate economy in the past two decades. This is because the conventional wisdom implies that monetary policy is sufficient enough to satisfy the requirement of the aggregate demand management (Gomes, 2010), therefore, Blanchard et al. (2010) stated, "......, fiscal policy took a backseat to monetary policy."

However, the resurgence of an interest in fiscal policy after its strong response during the "Great Recession" demonstrates that our current understanding, both empirically and theoretically, of this conventional policy instrument could be quite limited (Poterba, 2011). Because first of all, there is no agreement on the magnitudes of the stimulative effects of increasing government spending and reducing taxes on the aggregate economy. Second, although there was a widespread agreement that various categories of government spending and heterogenous types of taxes should generate different effects on the aggregate economy, as highlighted by Gomes (2010), Poterba (2011), and Rogoff (2011), the refined estimates of these heterogenous effects are quite scarce. In addition, there is no theoretical framework which could be employed to explain the potentially heterogenous effects of different government spending components on output and unemployment simultaneously.

In the literature, most of the existing studies evaluate the effects of labor market policies, which is the supply side of government intervention, on the aggregate economy for developed economies, for example, Siebert (1997), Nickell and Layard (1999), Belot and Van Ours (2001), Layard et al. (2005), Kahn (2012), Krebs and Scheffel (2013), and Blanchard et al. (2014), among many others. Studies about the impacts of labor market regulations on aggregate economy for developing countries, in particular, China, are quite limited.

As we articulated in Chapter 1, this dissertation attempts to examine three important questions. First, which category of the different government spending components, i.e., government wage expenditure, government investment, and government consumption, is more effective in boosting output and reducing unemployment, and why? Second, how do changes in different fiscal policies affect the labor market dynamics during recessions? Third, what are the effects of changing fiscal policies and labor market regulations simultaneously on the aggregate economy? Broadly speaking, the first two questions investigate the interactions between the fiscal policies and the labor market dynamics, while the third problem deals with the interactions of the labor market regulations and the fiscal policies in economies like China. Therefore, we first review the literature associated with fiscal policy and labor market dynamics, and then examine the literature related to fiscal policy and labor market regulations in economies like China.

2.2 Literature Review about Fiscal Policy and Labor Market Dynamics

The existing literature investigates the impacts of fiscal policy on labor market dynamics from the perspective of theoretical models, empirical studies, and quantitative evaluations. We review the literature from these three perspectives sequentially.

From the perspective of empirical studies, one stream of literature empirically examines the dynamic effects of government spending on output and labor market outcomes, for example, Bruckner and Pappa (2012), Monacelli et al. (2010), Uhlig (2010), Coenen et al. (2012b), and Kuo and Miyamoto (2014), among many others. However, these studies consider government expenditure as one homogenous compound, and none of them ever evaluated the potentially heterogenous impacts of different categories of government spending on output and unemployment simultaneously. It is important to examine the potentially different impacts of heterogenous government spending components on the aggregate economy, but this is overlooked in the literature, that's why Poterba (2011) and Rogoff (2011) argue that "different types of spending would have different effects, $\cdots\cdots$, there was a limited base of research available to refine estimates of these policy impacts".

Moreover, different identification strategies are employed to identify the impacts of government spending on output and unemployment in this stream of literature. The first identification strategy is the so called narrative approach, which employs the "war dates" in Ramey and Shapiro (1998) to identify the shocks of government spending, such as Edelberg et al. (1999), Burnside et al. (2004), and Ramey (2011). The second identification strategy is employing sign restrictions, which is imposed on the impulse response function, for example, Canova and Pappa (2007) and Mountford and Uhlig (2009) adopted such method in their study. The third identification strategy is to use robust theoretical restrictions, which is similar to sign restriction but implemented in a structural model, Campolmi et al. (2011) employed robust theoretical restrictions to estimate the effects of government spending, in addition, Pappa (2009) and Bermperoglou et al. (2012) also employed robust theoretical restrictions to isolate the different fiscal shocks. The fourth identification strategy is the zero short-run restrictions, which is pioneered by Blanchard and Perotti (2002), and extensively used by Perotti (2005), Galí et al. (2007), and Lendvai and Raciborski (2011), among many others. However, in the empirical literature concerning the U.S. economy so far, quite few studies ever employed this identification strategy to evaluate the impacts of different government spending shocks.

From the perspective of theoretical investigations, existing literature usually evaluates the impacts of fiscal policy on output and unemployment simultaneously, within the framework of a dynamic stochastic general equilibrium model with search frictions, such as, Monacelli et al. (2010), Bruckner and Pappa (2012), Burgert and Gomes (2011), Gomes (2011), Kato and Miyamoto (2013), and Kuo and Miyamoto (2014). However, the mechanisms through which *different* government spending components affect the aggregate output and unemployment are not clearly articulated in the literature, although Monacelli et al. (2010) explained the channels through which total government spending affects the aggregate economy[1]. Thus, Reis (2011) claims that "the mechanism by which government policy stimulates the economy in standard models is a caricature of reality at best". As far as we know, there is no theoretical framework, with both output and unemployment as equilibrium outcomes, where the transmission mechanisms of different government spending shocks are clearly characterized.

Moreover, a general feature of the existing frameworks is that their model environment is stochastic, with which only questions like whether the effects of unexpected changes in government spending on output and unemployment are positive or negative, and how large are these effects could be examined. However, employing these frameworks, questions like what would be the unemployment rate precisely at a specific point in time if government changes its fiscal policy during a certain period of time could not be exam-

[1]In Monacelli et al. (2010), Burgert and Gomes (2011), and Bermperoglou et al. (2012), the transmission mechanisms of government spending shock are affected by several structural parameters, but the characters of these structural parameters are not carefully evaluated.

ined.

From the perspective of quantitative evaluations, in the current literature, such as Monacelli et al. (2010) and Kuo and Miyamoto (2014), the patterns and magnitudes of the responses from simulation and those from estimations are compared. However, as government spending is one homogenous component in these studies, it is impossible for them to investigate the possibility of reallocating different government spending components so as to explore their aggregate effectiveness.

Furthermore, the Japanese economy fell into a liquidity trap in the 1990s according to Krugman et al. (1998) and Eggertsson and Woodford (2003), which restricts the characters of monetary policy to stimulate the economy. Thus, the effect of fiscal policy is especially interested by researchers and policy makers under this situation (e.g., Werning, 2011; Blanchard et al., 2010). However, few studies investigated the characters of fiscal policies during the 1990s of Japan, in particular, no existing study evaluated what would happen to the unemployment rate during the 1990s if the fiscal policies did not change.

2.3 Literature Review on China's Fiscal Policy and Labor Market Regulations

Considering the supply side government interventions, specifically, the character of labor market policies, in China, some literature examines the effects of labor mobility barriers, which is generated by the *hukou* system, on China's rising urban-rural income inequality, such as Cai et al. (2002), Liu (2005), Whalley and Zhang (2007), Fu (2013), and Zhu and Wan (2012). These studies highlight that labor mobility barriers distort regional labor allocation, which affects the average regional incomes, and hence increases urban-rural income inequality.

However, an important dimension through which labor mobility restrictions affects interregional income inequality has been ignored. Specifically, the associated regulations of *hukou* system exert negative impacts on the accumulation of human capital in the rural area, because it is difficult for rural children to benefit from the better education resources in urban areas. This channel is essentially the interaction of supply side policy and demand side policy, as the allocation of government spending across regions is affected by government fiscal policy, which is considered as the demand side policy of government intervention. It is important for economists and policy makers to know how their interaction affects the urban-rural income inequality, in particular, what would happen to the interregional income inequality if government changes these two policies simultaneously. But as far as we know, there is no theoretical framework which could be directly employed to answer these questions.

Moreover, the impacts of government spending on the enlarging urban-rural income inequality in China's rapid growth process has been repeatedly examined in the current studies, such as Chen et al. (2010), Wang et al. (2011), Wu et al. (2008), Wu (2011), and Treiman (2012). Public education spending affects the interregional income inequality because it directly affects the human capital accumulation in each region, which further influences the income. However, labor market interventions are abstracted from most of the frameworks in these studies, it is impossible to further explore the impacts of labor market policies within those existing models.

In addition, the relationships among human capital accumulation, regional income inequality, and economic growth have also been explored in the literature from the empirical perspective, such as Wei et al. (2001), Zhai et al. (2006), and Liu et al. (2011). However, there is no theoretical investigation about the mechanism behind their empirical findings, which is overlooked by the existing literature.

2.4 Contributions of This Dissertation

Generally speaking, this dissertation contributes to the existing literature theoretically, empirically, and quantitatively through completely assessing the impacts of the supply side government interventions, i.e., labor market regulations, the effects of different categories of the demand side government interventions, i.e., fiscal policies, as well as their interactions, on aggregate economy. More concretely, we highlight the contributions of this dissertation in each of the Chapter 3, Chapter 4, and Chapter 5, consecutively here.

Chapter 3 examines the dynamic heterogeneous effects of different government spending components on output and unemployment. Our study in Chapter 3 contributes to the existing literature mainly from three aspects. First, from the empirical perspective, we disaggregate the aggregate government spending into three components, i.e., government wage, consumption, and investment, and identify the shocks of each component through employing the zero short run restrictions, following Blanchard and Perotti (2002). As far as we know, our paper is the first study that employs historical data with zero short run restrictions to evaluate the heterogenous dynamic effects of different categories of government spending components on the aggregate economy[2]. In addition, we also provide a platform to compare the empirical findings from the literature using different identification strategies.

Second, from the theoretical perspective, we extended the standard dynamic stochastic general equilibrium model with search and matching frictions with five new features: (i) Heterogenous government expenditures as in Cortuk and Güler (2013); (ii) A productive government sector originates from Cavallo (2005); (iii) The complementarity between private goods and public goods in private consumption like Bruckner and Pappa (2012); (iv) Public physical capital externality in private sector production as in Baxter and King (1993); (v) Directed search à la Quadrini and Trigari (2007) and Gomes (2011). With this new theoretical framework, the characters of different government spending components are clearly characterized. Moreover, the mechanisms through which different government spending affect output and unemployment are explicitly characterized and articulated. In

[2] Burgert and Gomes (2011) examined the effects of different government spending elements on aggregate economy, but they employ simulated data, rather than historical data. Moreover, Bermperoglou et al. (2012) investigated the impacts of various government spending components on output and unemployment, however, they use structural estimation and impose several theoretical restrictions on their New Keynesian model with search frictions.

addition, the relative importance of each channel, as well as the characters of several important structural parameters are also investigated in our research.

Third, from the perspective of quantitative evaluations, we not only reproduce the order of government wage, consumption, and investment, according to their effectiveness in stimulating output and reducing unemployment, but also examine the potential effectiveness increment from reallocating government resources from the less effective component to the more effective component. To the best of our knowledge, this is the first paper that quantitatively evaluates the potential effectiveness increments about reallocating aggregate government spending among its different utilization purposes. In addition, our analysis suggests that during recessions, if government intends to effectively stimulates the economy, a larger proportion of the extra public spending ought to be spent on government wage expenditure.

Chapter 4 evaluates the impacts of changes in fiscal policies on labor market dynamics in Japan's Lost Decade. Our research in Chapter 4 makes three contributions to the current literature. First, from the theoretical aspect, we develop a dynamic general equilibrium model with search frictions in a deterministic environment as in Esteban-Pretel et al. (2010), which is further extended with two sectors: a private sector and a productive government sector, where the roles of different spending components are explicitly characterized and three categories of taxes with different characters are also introduced: labor tax affects the value of being employed, capital tax influences the capital accumulation, while consumption tax affects the wealth of the household. With the rich specification of fiscal policies, we could examine what would be the unemployment rate at a specific point in time if government changes its fiscal policy during a certain period of time, which could not be answered with a stochastic environment.

Second, from the quantitative perspective, our study not only demonstrates that changes in different government spending components as well as changes in different categories of taxes affect the unemployment rate heterogeneously during the 1990s of Japan, but also provides concrete measures concerning the effects of each fiscal policy change. In addition, we also provide intuitive explanations about why their effects are different.

Third, our research explores the characters of fiscal policies during recessions when the effect of monetary policy is restricted[3], which is interested by economists and policy makers, but was overlooked in the stream of literature examining Japan's Lost Decade. In addition, our study confirms that countercyclical fiscal policy contributes to stimulate the economy during recessions, and government ought to consider the different impacts of alternative fiscal policies when employing many fiscal instruments at the same time.

Chapter 5 investigates the characters of labor mobility barriers and urban-biased government education expenditures in affecting the enlarging urban-rural income inequality motivated by China's rapid growth era since 1978. Our investigations in Chapter 5 contribute to the existing literature mainly from three aspects. First, theoretically, we construct an analytical framework which could be employed to examine the characters of both labor market policies and fiscal policies. It is a growth model extended with two regions: urban area and rural area, where migration between these areas is costly, labor mobility barriers are introduced by assuming that they affect the migration cost. In addition, government education spending policies are introduced by adopting the assumption that individual's human capital accumulation is affected by government education spending per student.

Second, we qualitatively characterize the sources of urban-rural income inequality, analyze how government spending policies and labor market policies as well as their interaction affect the interregional income inequality in China. With the stationarity assumption of learning ability distribution, the log normal assumption of initial parental human capital distribution, and several tractability specifications of functional forms, we characterize the mean income for each region through aggregation under segregation and integration. Moreover, we evaluate the impacts of reducing labor mobility barriers and re-

[3]As Krugman et al. (1998) and Eggertsson and Woodford (2003) pointed out that the Japanese economy fell into a liquidity trap in the 1990s, which restricted the effectiveness of monetary policy to come into effect.

allocating government education spending on interregional income inequality, measured by the ratio of urban to rural mean incomes, through comparative dynamics analysis.

Third, we want to highlight that our framework is motivated by the stylized facts in China, however, it could also be applied to other emerging economies which share the similar government spending and labor market characteristics as in China.

From a more broader perspective, this dissertation also highlights the fact that in evaluating the impacts of different categories of government interventions on the aggregate economy, both the supply side policies and the demand side policies should be considered. Moreover, the interactions of policies from the supply side and the demand side should also be noted. We hope that the findings and implications of this dissertation would be very helpful for economists and policy makers.

Chapter 3

Heterogeneous Government Spending and Labor Market Dynamics: A Perspective from Directed Search

This chapter investigates the dynamic impacts of reallocating government expenditures across different spending components on output and labor market outcomes. To account for the empirical evidence that government wage expenditure, government investment, and government consumption expenditure affect output and the unemployment rate heterogeneously, we develop a directed search model with heterogeneous government expenditures and a productive government sector. Calibrating the model to the U.S. economy, we show that the model can generate the empirical pattern of the dynamic responses of output and unemployment to government spending shocks of each component, as well as the order of the cumulative output and unemployment rate multipliers. Through counterfactual experiments, we evaluate the quantitative effectiveness increments from reallocating government expenditures. We find that raising government wage expenditure financed by lowering government consumption expenditure generates the largest cumulative output and unemployment rate multipliers: 20 percent increase of government wage expenditure raises the cumulative output multiplier by 5.25 percent and reduces the cumulative unemployment rate multiplier by 8.22 percent, respectively. Our analysis suggests that reallocation of government resources can be an alternative to alleviate the rising government deficit.

3.1 Introduction

The large-scale response of fiscal policy during the "Great Recession" has ignited lots of studies about it in the recent literature. In particular, the effectiveness of increasing government spending to stimulate the economy and to cushion the labor market has been intensively examined (e.g., Monacelli et al., 2010; Uhlig, 2010; Campolmi et al., 2011; Bruckner and Pappa, 2012; Romer, 2012; Coenen et al., 2012b; Kuo and Miyamoto, 2014, among many others).

Most of these literature considers government spending as one homogeneous compound, and thus, an important dimension, the heterogenous components of government spending, has been overlooked. According to the National Income and Product Accounts (NIPA), the aggregate government spending is disaggregated into three components: government wage expenditure, government consumption expenditure, and government investment. This is illustrated in Figure 3.1a, where government wage expenditure is defined as compensation of general government employees, government consumption expenditure is the traditional government consumption expenditures minus government wage expenditure, and government investment equals government gross investment[1]. Meanwhile, each of these three components constitutes a substantial fraction of the total government spending, and no single component is neglectable. The composition of aggregate government spending is shown in Figure 3.1b, where we observe that the average share of government wage expenditure, government consumption expenditure, and government investment between 1954Q1 and 2012Q4 is 48.65%, 27.69%, and 23.33%, respectively.

One would expect that different categories of government expenditures might generate

[1]In NIPA Table 1.1.5, Line 22 "gross consumption expenditures and gross investment" corresponds to the government spending component in the expenditure approach of calculating gross domestic product (GDP). NIPA Table 3.9.5 clearly disaggregates this homogenous government spending into two elements: "government consumption expenditures" (Line 2) and "government gross investment" (Line 3). NIPA Table 3.10.5 implicitly disaggregates the "government consumption expenditures" into two more components: "compensation of general government employees" (Line 4) and the other consumption expenditures (Line 1 minus Line 4).

heterogenous impacts on output and labor market outcomes. As Table 3.1 shows that the time series properties of these three components are different: government consumption expenditure is more volatile, while government wage expenditure and government investment are more persistent. In addition, increasing government wage expenditure directly affects the labor market either through the intensive margin or by the extensive margin, while increasing government consumption expenditure or government investment only influences the labor market indirectly through the induced demand for labor.

Motivated by these observations, this paper quantitatively investigates the potential effectiveness increments from reallocating government expenditures across different spending components without changing its aggregate share in GDP. In particular, we focus on evaluating the cumulative output multipliers and cumulative unemployment rate multipliers, which are defined as the cumulative responses of output and unemployment rate to government spending shocks of each component within two years. This study is especially important under the context of large government deficit, which increases from 7.4 billions of dollars in 1954Q1 to 1332.7 billions of dollars in 2012Q4[2] in U.S.. To tackle the problem of this high and rising government deficit, most study (e.g., Auerbach and Gale, 2013; Coenen et al., 2012a; Denes et al., 2013; Nishiyama, 2014; and Nishiyama and Smetters, 2014) focuses on examining how to improve the structure of taxes from the revenue aspect, however, it is not easy to finance this huge government deficit only through collecting taxes. Moreover, it is difficult to cut government expenditures abruptly. Therefore, it is particularly important to evaluate the potential effectiveness increments from reallocating government expenditures across different spending components from the expenditure side.

To confirm whether the dynamic impacts of different government expenditures on output and labor market outcomes are heterogeneous or not, we perform an empirical analysis using a structural vector auto-regressive (SVAR) model. Our main empirical results

[2]The share of government deficit in GDP rises from 1.9% in 1954Q1 to 8.1% in 2012Q4, it reaches its highest value 11.3% in 2009Q3 in the United States of America.

reveal that the dynamic effects of government wage expenditure, government investment, and government consumption expenditure on output and unemployment rate are quantitatively heterogeneous. From the estimated peak and cumulative output multipliers as well as the peak and cumulative unemployment rate multipliers, government wage expenditure is the more effective component in boosting output and reducing unemployment rate, followed by government investment, while government consumption expenditure is the least effective element in stimulating the economy and cushioning the labor market[3].

We then develop a directed search model with heterogenous government spending and a productive government sector to account for our main empirical findings, as well as to quantitatively evaluate the potential effectiveness increments from reallocation. The production of government sector employs public physical capital, which is the accumulation of government investment, and public employment, which is affected by government wage expenditure. In particular, the share of public physical capital in government production directly influences the impacts of these two spending components on producing public product. Since government product is complementary to private goods in consumption, the magnitudes of the impacts of government wage expenditure and government investment on private consumption depend on the share of public physical capital. The model parameters are calibrated such that the steady state of the model matches the average data moments of the U.S. economy from 1954Q1 to 2012Q4. The calibrated model consistently captures the dynamic responses of output and unemployment rate to different government expenditure shocks, and reproduces the order of the cumulative output multipliers and cumulative unemployment rate multipliers for government wage expenditure, government investment, and government consumption expenditure.

Employing the calibrated model, we evaluate the effectiveness increments from reallocating government expenditures. Since our empirical analysis shows that government

[3]For example, the dynamic effects of different government expenditures on private investment, private hours worked, and private vacancy posting are heterogeneous not only quantitatively, but also qualitatively: increases in government wage expenditure and government consumption expenditure encourages vacancy posting and raises labor supply at the intensive, but government investment discourages vacancy posting and reduces labor supply at the intensive margin.

wage expenditure is the more effective component in stimulating output and reducing unemployment rate, the most promising counterfactual reallocation is to raise government wage expenditure financed through lowering the government consumption expenditure and/or government investment. In particular, we evaluate the potential effectiveness increments of a 20%[4] increase in government wage expenditures collected through four different financing scenarios: (i) the scheme of lowering the other two spending components equally; (ii) the scenario of lowering the other two elements unequally; (iii) the situation of only lowering government consumption expenditure; and (iv) the experiment of only lowering government investment, in our counterfactuals.

From the simulation results of our counterfactual experiments, we find that reallocating government resources from government consumption expenditure and/or government investment to government wage expenditure would improve the aggregate effectiveness of total government spending. In particular, 20% increase in government wage expenditure financed through only lowering government consumption expenditure is the most effective reallocation scheme, which increases the cumulative output multiplier by 5.25% and reduces the cumulative unemployment rate multiplier by 8.22%, respectively. Our analysis implies that, in recessions, government can effectively reduce the unemployment rate and boost output through reallocating the aggregate government spending among its different utilization purposes without inducing extra deficit.

To understand why government wage expenditure is the more effective component in stimulating the economy and cushioning the labor market, it is important to examine how different government spending components affect output and unemployment heterogeneously in our model. The dynamic impacts of government wage expenditure and government investment on output and unemployment are larger than that of government

[4]The share of aggregate government spending, government wage expenditure, government consumption expenditure, and government investment in GDP rises from 0.1913, 0.0958, 0.0524, 0.0402 in 2006Q4 to 0.2110, 0.1044, 0.0621. 0.0446 in 2009Q1, each of them increases by 10.35%, 8.98%, 12.50%, and 10.64%, respectively. If all the increment in aggregate government spending are devoted to government wage expenditure, it will rises from 0.0958 to 0.1156, i.e., 20.67% increase in the share of government wage expenditure, therefore, we employ the number 20% in our counterfactual experiment.

consumption expenditure, because these two components generate extra impacts on output and unemployment through government production. Moreover, since the magnitudes of these extra effects of government wage expenditure and government investment depend on the share of public physical capital in government production, with the larger share of government employment in the production of public goods, the magnitudes of the extra effect of government wage expenditure are larger than that of government investment[5].

The remainder of this paper is organized as follows. Section 3.2 briefly reviews the related literature and specifically articulates the contributions of this paper. Section 3.3 documents the stylized facts of output and the U.S. labor market and our empirical findings from the structural vector autoregressive (SVAR) model. Section 3.4 develops a directed search and matching model with heterogenous government expenditures and a productive government sector. We calibrate, simulate, and evaluate the model in section 3.5. In section 3.6, we examine the potential impacts of reallocating government expenditures through counterfactual experiments. Section 3.7 summarizes and discusses the potential research directions.

3.2 Literature Review

This paper belongs to the strand of literature that empirically examines the dynamic effects of government spending on output and labor market outcomes, for example, Bruckner and Pappa (2012), Monacelli et al. (2010), Uhlig (2010), Coenen et al. (2012b), and Kuo and Miyamoto (2014). However, these study considers government expenditure as one homogenous compound. In particular, Poterba (2011) and Rogoff (2011) claim that "different types of spending would have different effects, $\cdots\cdots$, there was a limited base of research available to refine estimates of these policy impacts". Therefore, this paper attempts to provide accurate and refined estimates of the dynamic impacts of different

[5] According to the estimates of Cubas (2011), the share of public physical capital is around 0.10, the extra effects of government wage expenditure is larger than that of government investment.

spending components using a SVAR model through clearly distinguishing different categories of government expenditures in our empirical section, which constitutes the first empirical contribution to the literature.

In the empirical literature, several identification schemes are employed to extract government spending shocks. Ramey and Shapiro (1998), Edelberg et al. (1999), Burnside et al. (2004), and Ramey (2011) employ a narrative approach. Canova and Pappa (2007) and Mountford and Uhlig (2009) use sign restrictions, Campolmi et al. (2011) employ robust theoretical restrictions to estimate the effects of government spending. Blanchard and Perotti (2002), Perotti (2005), Galí et al. (2007), and Lendvai and Raciborski (2011) use zero short-run restrictions to extract aggregate fiscal shocks. However, in the research that explicitly disaggregates government spending into three components, both Pappa (2009) and Bermperoglou et al. (2012) employ robust theoretical restrictions to isolate the different fiscal shocks. To the best of our knowledge, the empirical section of this paper is the first study that employs zero short-run restrictions to identify the shocks of different government expenditures[6], thus our empirical study provides a platform to compare whether different identification schemes of government spending shocks deliver similar results or not, which is the second empirical contribution to the literature.

Our study also belongs to the stream of literature that quantitatively evaluates the impacts of fiscal policy within the framework of a dynamic stochastic general equilibrium model with search frictions, such as, Kuo and Miyamoto (2014), where the transmission mechanisms of government spending shocks on output and labor market outcomes are similar to Monacelli et al. (2010). Reis (2011) claims that “the mechanism by which government policy stimulates the economy in standard models is a caricature of reality at

[6]Our analysis is closely related to the previous study of Burgert and Gomes (2011). Our theoretical framework is more general than theirs in the sense that we allow both extensive margin and intensive margin, private and public physical capital, complementarity between private goods and public goods in consumption, and public capital externality in production. In addition, our analysis differs from theirs in another three aspects: first, we employ historical data to examine the dynamic effects of different government expenditures, but they use simulated data in their study; second, we have three categories of government expenditures, but they disaggregate government spending into five components; third, we clearly articulate the propagation mechanisms of different government spending shocks, but they do not conduct such analysis.

best". Hence, our first theoretical contribution is that we construct a theoretical framework where the introduction of a productive government sector clearly characterizes the roles of different government expenditures, as well as the propagation mechanisms of different government spending shocks[7].

Moreover, à la Burgert and Gomes (2011) and Bermperoglou et al. (2012)[8], the propagation mechanisms of different government spending shocks in our framework are affected by different structural parameters, but they did not explicitly evaluate the relative importance of these structural parameters. Therefore, our second theoretical contribution is that we quantitatively evaluate the characters of different structural parameters in affecting the impacts of different government expenditure shocks on output and labor market outcomes.

Even in the literature that clearly disaggregates total government spending into several distinct components, such as Rotemberg and Woodford (1992), Rotemberg and Woodford (1992), Baxter and King (1993), Finn (1998), Lane and Perotti (1998), Schiantarelli et al. (2002), Lane (2003), Perotti (2007), and Pappa (2009), one important question that economists are interested in is omitted: whether it is possible to improve the aggregate effectiveness of total government expenditure through reallocation across its different spending components. To the best of our knowledge, this is the first paper that quantita-

[7]In our model, the propagation mechanisms of different government spending shocks are different from Monacelli et al. (2010), increasing government wage expenditure or government investment raises government production, due to the complementarity between private goods and public products, the marginal utility of private consumption increases, which increases the value of employment and decreases the value of unemployment, these two effects together raise the matching surplus, which further encourages vacancy posting and labor supply, resulting in an increase in output and a decrease in unemployment, i.e., the extra *surplus channel* of government wage expenditure or the extra *public physical capital accumulation channel* of government investment. In addition, by introducing public physical capital into the private sector production as in Baxter and King (1993), a *public physical capital externality channel* for government investment is characterized: rising government capital raises the marginal product of private inputs and thus the value of operating jobs, which increases the matching surplus, encourages vacancy posting and labor supply, hence output increases and unemployment decreases.

[8]Our paper is also related to Bermperoglou et al. (2012), but our study differs from theirs in four aspects: first, we use zero short run restrictions to identify different government spending shocks, while they employ sign restrictions to extract different shocks; second, our framework is a directed search model with heterogenous government expenditures and a productive government sector, while they employ a New Keynesian model with monopolistic competition and nominal price rigidities; third, we distinguish extensive margin with intensive margin, while they only consider extensive margin; fourth, their government sector is nonproductive.

tively evaluates the potential effectiveness increments and policy implications from reallocating aggregate government spending among its different utilization purposes, which constitutes our third theoretical contribution.

3.3 The Effects of Different Government Expenditures

To confirm whether the dynamic effects of different government expenditures are heterogenous or not, we employ a different identification strategy from Bermperoglou et al. (2012) and Pappa (2009). We first document some salient features of output and the labor market in the U.S. economy from 1954Q1 to 2012Q4, and then we conduct an empirical analysis using a structural vector autoregressive (SVAR) model.

Stylized Facts on U.S. Output and Labor Market Outcomes

Figure 3.2 presents the evolution of output and labor market variables in U.S. from 1954Q1 to 2012Q4. GDP per capita and private consumption per capita is calculated using the time series of aggregate GDP, aggregate private consumption, and population from Bureau of Economic Analysis (BEA). We obtain the unemployment rate from Bureau of Labor Statistics (BLS). The dynamics of unemployment is determined by the underlying flows out of and in unemployment, i.e., the job finding probability and the employment exit probability, which are constructed using the Current Population Survey (CPS) data following the method of Shimer (2012). The sources of other time series are stated in Appendix 3.D.

Three salient features are observed from Figure 3.2. First, although GDP per capita and private consumption per capita exhibit rising trend from 1954Q1 to 2012Q4, both of them decline during recessions. Second, the unemployment rate increases during recessions: On the one hand, the posted vacancy decreases, which increases the difficulty to find a job. On the other, the job finding probability decreases and the employment exit probability increases. Third, both the private hours worked and the private sector wage decrease during most of the recessions.

Empirical Analysis

We empirically investigate the dynamic impacts of different government spending shocks on output and labor market outcomes in U.S. through employing a structural vector autoregressive (SVAR) model in this section. Following Blanchard and Perotti (2002), Perotti (2005), Galí et al. (2007), and Ilzetzki et al. (2013), we identify different government spending shocks by assuming that these three components of government spending are not contemporaneously affected by the other variables in the model within a given quarter, due to implementation and decision lags of fiscal policy. This identification strategy is implemented through a Choleski decomposition with one component of government spending as the first variable, and substituting it with the other two components consecutively as in Tagkalakis (2013) and Burgert and Gomes (2011).

The benchmark specification consists of the following variables, à la Bruckner and Pappa (2012): the log of real per-employee government wage expenditure (replaced by the log of real per-capita government consumption expenditure, and the log of real per-capita government investment, respectively), the log of real per-capita GDP, the log of real per-capita private consumption, the log of real per-capita private investment, the real interest rate on 3-month T-bills; to this fixed set of variables, we add one more labor market variable in turn. The labor market variables that are consecutively included are: unemployment rate, vacancy posting index, private hours worked, real private wage index, job finding probability, and employment exit probability.

The sample period covers 1954Q1 to 2012Q4. The initial quarter is as in Monacelli et al. (2010), to avoid the impacts of turbulent spending and the Korean War. The final quarter is determined by the data availability of private hours worked. To partially tackle the effects of anticipated fiscal policy, we include a dummy variable with lags 0 to 4, taking value 1 on each of the three war dates indicated by Ramey and Shapiro (1998) and Ramey (2011). The SVAR model also includes a constant and a quadratic trend. The lag length of the SVAR model is based on information criteria and is set equal to one.

The dynamic responses of the main macroeconomic variables in the the U.S. economy to different expenditure shocks are summarized in Figure 3.3.1, while the dynamic effects of distinctive government spending shocks on the labor market outcomes are reported in Figure 3.3.2, and Figure 3.3.3. The magnitude of the shock to each component of government spending is *one* unit, following Stock and Watson (2001), the ± 1 standard error bands yielding an approximate 66% confidence interval for each of the endogenous variables are reported[9], which are constructed using bootstrap methods. We show the impulse response functions for a horizon of 40 quarters.

Figure 3.3.1 and Table 3.2.1 reveal three important observations about the responses of fundamental macroeconomic variables to different government spending shocks. First, the dynamic effects of government wage expenditure, government investment, and government consumption expenditure on output, private consumption, private investment, and real interest rate are indeed quantitatively heterogenous. According to the estimated peak(cumulative) output multipliers, output increases by 0.5959(3.3934), 0.0925(0.6847), and 0.0484(0.1936), respectively, after a one unit shock of government wage expenditure, government investment, and government consumption expenditure. Judging from the cumulative output multipliers, government wage expenditure is the more effective element in boosting output. Second, both output and private consumption respond positively after different government expenditure shocks, consistent with the findings of Monacelli et al. (2010) and Bruckner and Pappa (2012). Third, the contemporaneous impacts of government consumption expenditure shocks on private investment and real interest rate are negative, while the contemporaneous impacts of government wage expenditure and government investment on private investment and real interest rate are positive, hence, the dynamic impacts of different spending shocks on private investment and real interest rate are heterogeneous both quantitatively and qualitatively.

[9]Some literature studying the dynamic impacts of fiscal policy reports the 68% confidence interval, such as Ramey (2011) and Fisher and Peters (2010), which might appeal to Sims and Zha (1999). However, no formal justification for that particular choice is provided.

The responses of the labor market variables to different government expenditure shocks are summarized in Figure 3.3.2, Figure 3.3.3, Table 3.2.2, and Table 3.2.3, where four characteristics are demonstrated. First, the dynamic impacts of different government spending shocks on unemployment are quantitatively heterogenous. From the estimated peak(cumulative) unemployment rate multipliers, the unemployment rate decreases by 0.2116%(0.8271%), 0.0393%(0.2125%), and 0.0166%(0.0115%), respectively, after a one unit shock of government wage expenditure, government investment, and government consumption expenditure. Judging from the cumulative unemployment rate multipliers, government wage expenditure is the more effective component in reducing the unemployment rate. Second, after the one unit government spending shocks of each component, the job finding probability increases and the employment exit probability decreases, hence, the unemployment rate decreases, which are consistent with the empirical findings of Kuo and Miyamoto (2013) where aggregate government spending is employed. Third, although real private wage increases after different government expenditure shocks, the responses are not statistically significant. Fourth, the dynamic responses of vacancy posting and private hours worked to different government expenditure shocks are heterogenous not only quantitatively, but also qualitatively: their contemporaneous responses to government investment shocks are positive but these responses become negative after 2 quarters and 4 quarters, respectively; while their dynamic responses to government wage expenditure shocks are positive; their contemporaneous responses after the government consumption expenditure shock are negative but they become positive after 4 quarters and 3 quarters, respectively.

Discussion

Our empirical analysis demonstrates that the dynamic responses of output and the unemployment rate to different government spending shocks are quantitatively heterogenous. According to the cumulative output and unemployment rate multipliers, government wage expenditure is the more effective component in stimulating the economy and cushioning the labor market, which is consistent with the findings of Bermperoglou et al. (2013) and Burgert and Gomes (2011) with different identification strategies. In addition, the dynamic responses of private investment, real interest rate, private hours worked, and vacancy posting are heterogenous both quantitatively and qualitatively. Our empirical findings confirm that the dynamic effects of different government expenditures on output and labor market outcomes are heterogenous.

Although there are some debates about the identification of government spending shocks using zero short-run restrictions, the identification strategy proposed by Blanchard and Perotti (2002) is still one of the most widely employed methods in the literature of analyzing the impacts of government spending shocks, detailed discussion of this issue is well beyond the scope of this paper. Moreover, our main empirical findings about the responses of output and labor market variables are consistent with the existing empirical observations in the literature. In particular, by employing a robust theoretical sign restrictions Bermperoglou et al. (2013) find that government wage expenditure is the more effective component in stimulating output. Burgert and Gomes (2011) also show that average wage and employment have bigger output multipliers than other components.

Why are the dynamic effects of different government spending shocks on output and labor market outcomes heterogenous? In particular, why does government wage expenditure generate the largest cumulative output and unemployment multipliers? We develop a two-sector dynamic stochastic general equilibrium (DSGE) model with heterogenous government expenditures and a productive public sector to explore these problems by examining the mechanisms through which different government spending shocks affect output and labor market outcomes.

3.4 The Model

To account for our main empirical evidence that different categories of government spending components affect output and labor market outcomes heterogeneously, following

Quadrini and Trigari (2007) and Gomes (2011), we develop a directed search model with heterogenous components of government spending à la Bermperoglou et al. (2012) and a productive role of government sector as in Cortuk and Güler (2013). There is a private sector and a public sector in the model, where time is discrete and agents are infinitely lived.

Labor Market

The labor market is subject to search and matching frictions as in Mortensen and Pissarides (1994), and the economy-wide total labor force is normalized to be 1. At period t, individuals are either private employees (n_t^p), or public employees (n_t^g), or unemployed (u_t), so

$$n_t^p + n_t^g + u_t = 1. \tag{3.1}$$

The unemployed individuals and firms could not meet instantaneously in the labor market due to the presence of searching and matching frictions. The number of vacancies posted in sector i is v_t^i, for each $i \in \{p, g\}$. The unemployed workers can choose which sector to search in, hence the number of unemployed searching in sector i is u_t^i, for each $i \in \{p, g\}$. The new matches are characterized by the standard Cobb-Douglas matching functions

$$m_t^i = \eta^i \left(u_t^i\right)^{\mu^i} \left(v_t^i\right)^{1-\mu^i}, \text{ for each } i \in \{p, g\}. \tag{3.2}$$

where η^i measures the matching efficiency and μ^i indicates the elasticity of m_t^i with respect to u_t^i in sector i. Let $s_t = \frac{u_t^g}{u_t}$ be the fraction of unemployed searching for public jobs[10], where $u_t = u_t^p + u_t^g$. The conditional vacancy filling probabilities q_t^i and the conditional job finding probabilities p_t^i are

[10] As noted by Gomes (2011) and Burgert and Gomes (2011), the number of vacancies posted in sector i only simultaneously affect the vacancy filling probability in the other sector $-i$ due to the assumption of directed search.

$$q_t^i = \frac{m_t^i}{v_t^i}, p_t^i = \frac{m_t^i}{u_t^i}, \text{ for each } i \in \{p, g\}. \tag{3.3}$$

Following the search and matching literature (e.g., Lubik, 2009), the new matches will be productive in one period. While the operating matches in sector i face the exogenous destruction rate λ^i, for each $i \in \{p, g\}$, at the end of period t. The evolution of employed workers in sector i is

$$n_t^i = m_{t-1}^i + \left(1 - \lambda^i\right) n_{t-1}^i, \text{ for each } i \in \{p, g\}. \tag{3.4}$$

Households

The representative household consists of a continuum of individuals of mass one. As in Merz (1995), the incomes of all family members are pooled together and equally allocated such that they perfectly insure each other[11]. In period t, a fraction of n_t^p of the family members are working in the private sector, a proportion of n_t^g are working in the public sector, while a fraction of u_t are unemployed.

Following Linnemann and Schabert (2003) and Bouakez and Rebei (2007), household's utility depends on the consumption of private goods c_t^p, government products c_t^g, as well as hours worked in each sector h_t^i[12], for each $i \in \{p, g\}$. The household has the following per period utility

$$u(c_t) - v\left(n_t^p, h_t^p, n_t^g, h_t^g\right). \tag{3.5}$$

where

$$u(c_t) = \frac{c_t^{1-\sigma} - 1}{1-\sigma}, \text{ and } c_t = \left[\phi \left(c_t^p\right)^{\frac{\zeta-1}{\zeta}} + (1-\phi)\left(c_t^g\right)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{\zeta}{\zeta-1}}. \tag{3.6}$$

[11]Andolfatto (1996) provides an alternative approach to model complete markets in an economy with search and matching frictions.

[12]Different from the standard DSGE model, the hours worked in the private sector is not endogenously chosen by the individual, instead it is negotiated through Nash bargaining.

and

$$\nu\left(n_t^p, h_t^p, n_t^g, h_t^g\right) = \psi n_t^p \frac{\left(h_t^p\right)^{1+\varsigma}}{1+\varsigma} + \psi n_t^g \frac{\left(h_t^g\right)^{1+\varsigma}}{1+\varsigma}. \tag{3.7}$$

where $\beta \in (0,1)$ indicates the subjective discount factor of households. c_t is the effective consumption as in Bouakez and Rebei (2007). ψ is a positive number and indicates the disutility of working. $\frac{1}{\varsigma}$ is the Frisch elasticity of labor supply. σ is the inverse of the intertemporal elasticity of substitution. ζ indicates the elasticity of substitution between private consumption and government production. $1-\phi$ measures the degree to which government production affects utility.

The household chooses consumption and physical capital holdings each period $\left\{c_t^p, K_{t+1}^p\right\}_{t=0}^{\infty}$ while considering $\left\{c_t^g\right\}_{t=0}^{\infty}$ as given to maximize the expected discounted lifetime utility

$$\max_{\left\{c_t^p, K_{t+1}^p\right\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[u\left(c_t\right) - \nu\left(n_t^p, h_t^p, n_t^g, h_t^g\right)\right]. \tag{3.8}$$

subject to

$$\begin{aligned} c_t^p + I_t^p &= w_t^p h_t^p n_t^p + w_t^g h_t^g n_t^g + u_t z_t + r_t^p K_t^p + \Pi_t - T_t, \\ &\quad \text{given } K_0 \end{aligned} \tag{3.9}$$

where w_t^i is the wage rate for the household members working in sector i , for each $i \in \{p, g\}$. z_t is the unemployment benefits. Π_t is the profits from firms. T_t is the lump sum taxes paid by the household. I_t^p is the household investment. r_t^p is the real rental rate of private capital K_t^p, which evolves according to

$$K_{t+1}^p = I_t^p + (1-\delta^p) K_t^p. \tag{3.10}$$

where δ^p is the depreciation rate of private capital.

The household's optimal decisions about c_t^p and K_{t+1}^p , taking c_t^g as given, are characterized by the following first order conditions (FOCs)

$$\left[\phi\left(c_t^p\right)^{\frac{\zeta-1}{\zeta}}+(1-\phi)\left(c_t^g\right)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{1-\sigma\zeta}{\zeta-1}}\phi\left(c_t^p\right)^{\frac{-1}{\zeta}} = \varphi_t. \tag{3.11}$$

$$\beta\mathbb{E}_t\varphi_{t+1}\left(1+r_{t+1}^p-\delta^p\right) = \varphi_t. \tag{3.12}$$

where φ_t is the Lagrange multiplier of the budget constraint. In particular, equation (3.11) and equation (3.12) constitute the traditional consumption-Euler equation, which indicates that the marginal benefit of consuming today should be equal to the marginal cost of current consuming at the optimal.

Workers

Let W_t^i and U_t^i represent the value of an employed worker and the value of a unemployed worker in sector i at period t, respectively, for each $i \in \{p,g\}$. The Bellman equation for the employed worker in sector i at period t is characterized by

$$W_t^i = w_t^i h_t^i - \psi\frac{\left(h_t^i\right)^{1+\varsigma}}{\varphi_t\left(1+\varsigma\right)}+\beta\mathbb{E}_t\frac{\varphi_{t+1}}{\varphi_t}\left[\left(1-\lambda^i\right)W_{t+1}^i+\lambda^i U_{t+1}^i\right]. \tag{3.13}$$

where the left hand side of (3.13) represents the opportunity cost of holding asset W_t^i. The right hand side in (3.13) can be interpreted as the dividend flow from the asset, i.e., the labor income, the disutility of working in terms of consumption, and the continuation value in terms of consumption: the value of being employed in the following period if the match survives, or the value of being unemployed if it is destroyed at period $t+1$. With the assumption of directed search, the unemployed can choose which sector to search for a job.

The Bellman equation for the unemployed worker searching in sector i at period t is represented through

$$U_t^i = z_t + \beta \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} \left[p_t^i W_{t+1}^i + \left(1 - p_t^i\right) U_{t+1}^i \right]. \tag{3.14}$$

where p_t^i is the conditional job finding probability in sector i at time t, for each $i \in \{p, g\}$. The left hand side of (3.14) is the opportunity cost of holding asset U_t^i. The right hand side of (3.14) consists of the unemployment benefit or the value of home production, and the continuation value: the potential gains from finding a job in sector i in the following period, or the value of being unemployed at time $t+1$ if failing to get a job in sector i, for each $i \in \{p, g\}$.

In equilibrium, the value of searching in the private sector and that of searching in the public sector should be equalized, i.e.,

$$U_t^p = U_t^g = U_t. \tag{3.15}$$

where (3.15) determines the equilibrium share of unemployed searching in sector i, for each $i \in \{p, g\}$. Combining with (3.14), it can be expressed as

$$\frac{m_t^p \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} \left(W_{t+1}^p - U_{t+1}\right)}{1 - s_t} = \frac{m_t^g \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} \left(W_{t+1}^g - U_{t+1}\right)}{s_t}. \tag{3.16}$$

where (3.16) implicitly determines the share of workers searching in the public sector s_t. An increase in the value of being employed in the private sector, driven by either an increase in the wage, a decrease in the destruction rate, or an increase in the working hours in the private sector iff $w_t^p > \frac{\psi\left(h_t^i\right)^{\varsigma}}{\varphi_t}$, reduces the share of unemployed searching in the public sector s_t. In addition to the public sector wage, the hours worked in the private sector also affect the equilibrium s_t under certain conditions.

Private Sector Firms

Private sector firms employ private physical capital, the household's labor, and the economy wide public physical capital as in Baxter and King (1993) to produce private goods. The production function of private firm is constant returns to scale (CRS), and it is

$$y_t^p = a_t^p \left(k_t^p\right)^{\alpha_p} \left(h_t^p\right)^{1-\alpha_p} \left(K_t^g\right)^{\alpha_g}. \tag{3.17}$$

where a_t^p is the aggregate productivity shock to private sector firms. k_t^p is the private capital per worker. K_t^g is the aggregate public capital, which captures the character of public physical capital externality. $\alpha_p \in (0,1)$ indicates the output elasticity with respect to private capital, and $\alpha_g \in (0,1)$ measures the output elasticity with respect to public capital.

Let J_t and V_t indicate the the value of an operating job and the value of a vacant job, respectively. The Bellman equation of an operating firm is

$$J_t = \max_{k_t^p} \left\{ y_t^p - w_t^p h_t^p - r_t^p k_t^p + \beta \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} \left[(1-\lambda^p) J_{t+1} + \lambda^p V_{t+1} \right] \right\}. \tag{3.18}$$

where the left hand side of (3.18) is the opportunity cost of holding the asset J_t . The right hand side of (3.18) consists of the current profits, and the continuation value: the firms obtains J_{t+1} with probability $1-\lambda^p$ if the job is not destroyed, and gets V_{t+1} with probability λ^p if the match is destroyed in the next period $t+1$.

The first order condition for private capital demand is

$$a_t^p \alpha_p \left(k_t^p\right)^{\alpha_p - 1} \left(h_t^p\right)^{1-\alpha_p} \left(K_t^g\right)^{\alpha_g} = r_t^p. \tag{3.19}$$

equation (3.19) implies that the marginal product of private capital should be equal to its rental rate at the optimal. The total profit of the private firm is

$$\Pi_t = \left[a_t^p \left(k_t^p\right)^{\alpha_p} \left(h_t^p\right)^{1-\alpha_p} \left(K_t^g\right)^{\alpha_g} - w_t^p h_t^p - r_t^p k_t^p \right] n_t^p - \iota^p v_t^p. \tag{3.20}$$

The Bellman equation of a vacant job is

$$V_t = -\iota^p + \beta \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} \left[q_t^p J_{t+1} + \left(1 - q_t^p\right) V_{t+1} \right]. \tag{3.21}$$

where ι^p is the vacancy posting cost, and q_t^p is the job filling probability in the private sector at time t. In equilibrium, any profit of new jobs is exhausted, the free entry condition $V_t = V_{t+1} = 0$ implies that

$$0 = -\iota^p + \beta \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} q_t^p J_{t+1}. \tag{3.22}$$

Combining (3.18) and (3.22) with the free entry condition, we obtain the job creation condition in the private sector

$$\frac{\iota^p}{q_t^p} = \beta \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} \left[y_{t+1}^p - w_{t+1}^p h_{t+1}^p - r_{t+1}^p k_{t+1}^p + (1 - \lambda^p) \frac{\iota^p}{q_{t+1}^p} \right]. \tag{3.23}$$

The left hand side of (3.23), which is the expected vacancy posting cost, should be equal to the sight hand side of (3.23), which is the firm's share of the expected surplus from the new match.

Surplus, Bargaining, Wages, and Hours Choice

When a match becomes productive, it creates a surplus S_t which is shared between the private firm and the worker. The surplus S_t is the sum of the values of an employed worker W_t^p and an operating job J_t minus their outside options, i.e., the value of being unemployed U_t^p and the value of a vacant job V_t, respectively. Because of free entry condition, in equilibrium $V_t = 0$. Therefore, the surplus is $S_t = W_t^p - U_t^p + J_t$.

Wages and hours worked in the private sector are determined through Nash bargaining between the workers and firms in the private sector. In period t, private wages and hours worked are negotiated to maximize the Nash product

$$\max_{w_t^p, h_t^p} \left(W_t^p - U_t^p\right)^{\xi} \left(J_t - V_t\right)^{1-\xi}. \tag{3.24}$$

where $\xi \in (0,1)$ is the worker's bargaining power.

The Nash bargaining problem (e.g., Binmore et al., 1986) implies that both private firms and workers receive a constant fraction of the surplus. The optimal sharing rules are:

$$W_t^p - U_t^p = \xi S_t \text{ and } J_t = (1-\xi) S_t. \tag{3.25}$$

Combining equation (3.25) with equations(3.13), (3.14), (3.18), and (3.21) delivers

$$S_t = y_t^p - r_t^p k_t^p - \psi \frac{\left(h_t^p\right)^{1+\varsigma}}{\varphi_t (1+\varsigma)} - z_t + (1-\lambda^p) \frac{\iota^p}{q_t^p} + \left(1-\lambda^p - p_t^p\right) \frac{\xi}{1-\xi} \frac{\iota^p}{q_t^p}. \tag{3.26}$$

The division of surplus between private firms and workers delivers the wage w_t^p and hours worked h_t^p[13] in the private sector

$$w_t^p h_t^p = \xi \left(y_t^p - r_t^p k_t^p + \iota^p \frac{v_t^p}{u_t^p} \right) + (1-\xi) \left[\psi \frac{\left(h_t^p\right)^{1+\varsigma}}{\varphi_t (1+\varsigma)} + z_t \right]. \tag{3.27}$$

$$\psi \frac{\left(h_t^p\right)^{\varsigma}}{\varphi_t} = a_t^p (1-\alpha_p) \left(k_t^p\right)^{\alpha_p} \left(h_t^p\right)^{-\alpha_p} \left(K_t^g\right)^{\alpha_g}. \tag{3.28}$$

where equation (3.27) is similar to the wage equation in Pissarides (2000). The left hand side of (3.27) is the private wage income, while the right hand side of (3.27) is a weighted average of the marginal product of a worker, and the cost of recruiting a worker, which consists of the disutility of working and the unemployment insurance.

The hours worked in the private sector is determined by (3.28). Its left hand side is the marginal cost of working, which should equal to its right hand side, the marginal benefit of working at the optimal.

[13] As shown in Trigari (2009) and Trigari (2004), the private hours worked negotiated through Nash bargaining is equivalent to that determined to maximize the joint surplus of the match if private wage is set to divide the joint surplus based on the bargaining power ξ.

Government Sector

On top of collecting taxes to finance expenditures, the government sector produces public or government goods y_t^g through employing public capital K_t^g, which is affected by government investment, and total hours worked in the public sector $n_t^g h_t^g$, which is affected by government wage expenditure, following Cavallo (2005).

As in Cortuk and Güler (2013) and Gomes (2012), to avoid double counting, public good is not sold and thus it is not a component of total output. The numeraire of the economy is private consumption good. There are two characters of the government goods. First, it forms effective consumption c_t with private goods c_t^p. Second, the vacancy posting cost in the government sector is compensated using government production. The production function for government good is

$$y_t^g = a_t^g \left(K_t^g\right)^\gamma \left(n_t^g h_t^g\right)^{1-\gamma}. \tag{3.29}$$

where $\gamma \in (0,1)$ measures the public goods elasticity with respect to public capital. a_t^g is the aggregate productivity shock to government sector firms. Let ι^g be the vacancy posting cost in the public sector, thus the net output of the public sector c_t^g, which is employed to indicate government goods, is

$$c_t^g = a_t^g \left(K_t^g\right)^\gamma \left(n_t^g h_t^g\right)^{1-\gamma} - \iota^g v_t^g. \tag{3.30}$$

where government physical capital K_t^g is accumulated through government investment I_t^g, and it evolves as

$$K_{t+1}^g = (1-\delta^g) K_t^g + I_t^g. \tag{3.31}$$

The government impose a lump sum tax T_t to finance wage expenditure $w_t^g n_t^g h_t^g$, investment expenditure I_t^g, consumption expenditure g_t^g, and unemployment insurance z_t, the government budget constraint is

$$T_t = w_t^g n_t^g h_t^g + I_t^g + g_t^g + u_t z_t. \tag{3.32}$$

According to Blanchflower (1996) and Gregory and Borland (1999), the average public sector wages are 1.34% to13.34% higher than average private sector wages. Considering these facts of pub wage premium and following Michaillat (2011), the government wage is specified as

$$w_t^g = (1 + \pi^g) w_t^p \tag{3.33}$$

where π^g is a parameter measuring the net premium of government wage.

Because public sector wage w_t^g and public sector employment n_t^g are endogenous in our model, the shock to government wage expenditure only stems from hours worked in the public sector h_t^g. The government sets $\left\{v_t^g, h_t^g, I_t^g, g_t^g, z_t\right\}_{t=0}^{\infty}$, where $\left\{h_t^g, I_t^g, g_t^g\right\}_{t=0}^{\infty}$ are assumed to evolve exogenously according to

$$h_t^g = \left(\bar{h}^g\right)^{1-\rho_{hg}} \left(h_{t-1}^g\right)^{\rho_{hg}} e^{\varepsilon_t^{hg}} \tag{3.34}$$

$$I_t^g = \left(\bar{I}^g\right)^{1-\rho_{Ig}} \left(I_{t-1}^g\right)^{\rho_{Ig}} e^{\varepsilon_t^{Ig}} \tag{3.35}$$

$$g_t^g = \left(\bar{g}^g\right)^{1-\rho_{gg}} \left(g_{t-1}^g\right)^{\rho_{gg}} e^{\varepsilon_t^{gg}} \tag{3.36}$$

where $\bar{x}^g$ is the steady state values of x, $\rho_{xg} \in (0,1)$, ε_t^{xg} is an independently and identically distributed, i.e., i.i.d., shock to x with constant variance $(\sigma^{xg})^2$, for each $x \in \{h, I, g\}$.

Decentralized Equilibrium

To close the model, we characterize the equilibrium that we are interested in. The definition of decentralized equilibrium below summarizes the overall framework of our model.

Definition 1. A decentralized equilibrium is a sequence of private wages and interest rates $\{w_t^p, r_t^p\}_{t=0}^{\infty}$, a sequence of private hours worked $\{h_t^p\}_{t=0}^{\infty}$ such that, given a sequence of government vacancies, investment, consumptions, public hours worked, and unemployment insurance $\{v_t^g, I_t^g, g_t^g, h_t^g, z_t\}_{t=0}^{\infty}$, the household chooses a sequence of consumption and saving $\{c_t^p, K_{t+1}^p\}_{t=0}^{\infty}$, firms choose a sequence of private vacancies and saving $\{v_t^p, k_t^p\}_{t=0}^{\infty}$ to satisfy:

(a) Agents optimize:

$(a.1)$ The household's maximization conditions (3.11) and (3.12) are satisfied;

$(a.2)$ The value functions in the labor market (3.13), (3.14), (3.18), (3.21) are met;

$(a.3)$ The private sector physical capital demand should satisfy (3.19);

$(a.4)$ The optimal surplus sharing rule in the private sector (3.25) are satisfied;

$(a.5)$ The private wage (3.27) and hours worked (3.28) solves the Nash bargaining;

$(a.6)$ The vacancy posting in the private sector satisfy the job creation condition (3.23);

(b) Markets clear:

$(b.1)$ The aggregate demand for final goods satisfies $Y_t = c_t^p + I_t^p + T_t + v_t^p \iota^p$;

$(b.2)$ The aggregate supply for final goods should meet $Y_t = n_t^p y_t^p$ such that final goods market clears;

$(b.3)$ The aggregate supply and aggregate demand for private capital satisfy $K_t^p = n_t^p k_t^p$ to clear the private capital market;

$(b.4)$ The labor market should satisfy (3.1) and (3.4) in equilibrium;

(c) Government behavior:

$(c.1)$ The government budget should satisfy (3.32);

$(c.2)$ The government sector wage should meet (3.33);

$(c.3)$ The government production should meet (3.30);

(d) The evolution of the whole system is governed by the law of motions for labor (3.4); the law of motion for capital (3.10) and (3.31); as well as the exogenous stochastic processes (3.34), (3.35), and (3.36).

To numerically solve the model, we summarize the system of nonlinear equations that characterize the decentralized equilibrium of this economy in Appendix 3.G. The steady state of the model economy is a decentralized equilibrium in which all stationary variables are constant, which is characterized in Appendix 3.H.

3.5 Calibration

To simulate the model, we need to provide values for the parameters and for the exogenous variables of it. We first explain the calibration strategies, then solve the model by approximating the equilibrium conditions near a non-stochastic steady state. After that, we validate the model by examining its static and dynamic properties as well as the robustness through simulations.

Calibration

The model parameters are calibrated such that the steady state of the model matches the average data moments of the U.S. economy from 1954Q1 to 2012Q4. The period in the model is one quarter.

As in Gomes (2011), in the benchmark calibration, the steady state vacancies in the public sector v^g are such that the government employment n^g corresponds to the average share of government employees from 1954Q1 to 2012Q4, i.e., 14% of the labor force.

To calibrate the sectoral elasticity of matching with respect to vacancies, we run a regression of the log of private (government) job finding rate, which is defined by the ratio between private (government) hires and unemployment, on the log of private (government) tightness, which is defined by the ratio between private (government) job openings and unemployment, respectively. The estimated coefficients are 0.5820 for the private sector and 0.8682 for the public sector. We set the private and government matching elasticities with respect to sectoral unemployment μ^p and μ^g at 0.50 and 0.20, respectively, both are slightly higher than our estimates but consistent with Petrongolo and Pissarides (2001).

According to the empirical findings of Davis et al. (2013), the average vacancy duration in the private sector is 20 days, while the mean government vacancy duration is 50 days, we calibrate the matching efficiency parameter η^p and η^g to match these two moments, which implies that $q^p = 4.5$ and $q^g = 1.8$.

The sectoral vacancy posting costs ι^p and ι^g are set at 2.0 and 1.10, respectively, such that the sum of the recruitment costs in our benchmark calibration is 0.0264 percent of the total labor cost, which is above 0.0250 percent in Burgert and Gomes (2011), but close to the estimate 0.03 percent by Russo et al. (2005).

The empirical estimation of Gregory and Borland (1999) indicates that the public sector wage premium is between 0.02 and 0.10, we set the government wage premium π^g at 0.02 in our benchmark calibration following Bermperoglou et al. (2012).

The discount factor β is chosen to be 0.99, which implies a 1% quarterly real interest rate approximately. The share of capital in the production of the private sector α^p is set at 0.33, consistent with the data of capital share in U.S. economy.

The private separation rate λ^p is calibrated such that the share of private employment in total labor force is 0.80, which is the average share of private employment from 1954Q1 to 2012Q4. As in Esteban-Pretel and Faraglia (2010), the the disutility of working is calibrated such that the steady state hours worked is 0.33. According to the Hosios (1990) condition, we pin down the private bargaining power $\xi = 0.50$.

The public separation rate λ^g is set at 0.03 like Burgert and Gomes (2011), which is consistent with the data moment from Job Openings and Labor Turnover Survey (JOLTS). Following the conventions in the literature, the quarterly depreciation rate of private capital δ^p is set at 0.025 as in Monacelli et al. (2010), and the depreciation rate of public capital δ^g is set at 0.02 as in Baxter and King (1993).

In our benchmark simulation, the share of private consumption is set at $\phi = 0.70$ as in Bruckner and Pappa (2012), as this structural parameter is important in affecting the surplus channel, we also employ $\phi = 0.30$ and $\phi = 1.00$ to evaluate its quantitative importance.

The consumption substitutability ζ is set at $\zeta = 0.40$ as in Bruckner and Pappa (2012). According to the estimates of Gándelman and Hernández-Murillo (2014), the relative risk aversion σ is set to 2.0 to capture the more concave function than the log utility function for the U.S. economy[14].

The Frisch elasticity inverse ς is set at 1.0 as in Reichling and Whalen (2012) in our benchmark simulation, then we use $\varsigma = 0.50$ and $\varsigma = 1.50$ to examine whether our simulation results are sensitive to the choice of the convexity of labor supply or not.

The contribution of public physical capital in private production α^g is set at 0.05 in the benchmark following Baxter and King (1993), since α^g affects the public physical capital externality channel, we evaluate its quantitative significance by alternative values[15].

The share of public physical capital in government production γ is set to be 0.10 according to the estimate in Cubas (2011), we then examine the robustness of our simulation results to different values of γ[16]. Following the same calibration strategy as in Bermperoglou et al. (2012), both the private technology shock and public technology shock are normalized to be 1, i.e., $a^p = 1.0$ and $a^g = 1.0$.

The autocorrelation coefficients of hours worked in the public sector, government investment, and government consumption expenditure are calibrated to match the data moments[17], which implies $\rho_{hg} = 0.9839$, $\rho_{Ig} = 0.9080$, $\rho_{gg} = 0.8969$. The standard de-

[14]The estimate of σ for the US is 1.37, which indicates more concave functions. In addition, we also employ $\sigma = 1.0$ in our alternative calibration, the simulation results demonstrate that the order of the cumulative multipliers remains.

[15]We conducted robustness check employing both lower and higher values for this parameter, i.e., $\alpha^g = 0.01$ and $\alpha^g = 0.15$, the simulation results deliver exactly the same order of effectiveness in terms of the simulated cumulative output and unemployment multipliers. In addition, Table 3.A.3 on page 87 of the dissertation reports the simulation results using $\alpha^g = 0.00$, where wage component is still the most effective element, followed by investment, and consumption is the least element, thus our results are robust to this parameter values.

[16]We conducted robustness check employing both lower and higher values for this parameter, i.e., $\gamma = 0.05$ and $\gamma = 0.15$, the simulation results deliver exactly the same order of effectiveness in terms of the simulated cumulative output and unemployment multipliers. In addition, Table 3.A.1 on page 81 of the dissertation reports the simulation results using $\gamma = 0.15$, where wage component is still the most effective element, followed by investment, and consumption is the least element, thus our results are robust to this parameter selection.

[17]Theoretically, the persistency of the shock really matters for the size of responses of endogenous variables (e.g., Mayer et al., 2010; Kuo and Miyamoto, 2014; and Kato and Miyamoto, 2013), we carefully calibrate the autocorrelation coefficients with the data moments from the corresponding Hodrick-Prescott (1997) filtered time series of the shares of government wage expenditure, government investment, and

viation of the hours worked in the public sector, government investment, and government consumption expenditure are calibrated to match the corresponding data moment, i.e., $\sigma^{hg} = 0.0065$, $\sigma^{Ig} = 0.0030$, and $\sigma^{gg} = 0.0045$. The exogenously assigned parameter values are summarized in Table 3.3.1, the parameter values that are set to match certain data moments are reported in Table 3.3.2, and the endogenously calibrated parameter values are shown in Table 3.3.3.

Under the above calibration strategies, the steady state solutions of the targeted endogenous variables are summarized in Table 3.4.1, where we find that the steady state unemployment rate, share of people working in the private sector, share of people working in the public sector, the steady state hours worked in the private sector, the private vacancy filling rate, and the public vacancy filling rate are all equal to their targeted values. In addition, the predicted values of the other endogenous variables reported in Table 3.4.2, where we find that these predicted values are quite close to their corresponding data moments. Therefore, in terms of the static properties, our model could capture the characteristics of the economy very well.

The Simulated Effects of Different Government Expenditures

To evaluate the dynamic properties of our model, we examine the pattern of the responses of output and labor market outcomes to different government spending shocks of magnitude *one* through stochastic simulations.

The dynamic responses of fundamental macroeconomic variables to different government expenditure shocks are reported in Figure 3.4.1 and Table 3.5.1, where three salient features are observed. First, the simulated dynamic impacts of different government expenditures shocks on output, private consumption, private investment, and real interest rate are quantitatively heterogeneous. In particular, our model successfully reproduces the order of the cumulative output multipliers[18], i.e., output increases by 3.1936, 1.7162, and

government consumption expenditure in GDP.

[18]Our definition of fiscal output multiplier and fiscal unemployment multiplier follows the standard definition as in Spilimbergo et al. (2009) and Chinn (2013). A detailed description of the fiscal multiplier can

1.5079, respectively, in our benchmark simulation, after a one unit shock of government wage expenditure, government investment, and government consumption expenditure. Therefore, government wage expenditure is the more effective component in stimulating output, which is consistent with our empirical finding. Second, private consumption decreases after government investment shock and government consumption expenditure shock, consistent with the simulation results from the standard dynamic stochastic general equilibrium model with search frictions. However, private consumption increases after government wage expenditure shock, because increasing government wage expenditure increases public production which is complementary to private consumption, and this complementarity raises the marginal utility of private consumption, thus private consumption increases. Third, the real interest rate increases and private investment decreases after different government spending shocks, consistent with the simulation results of Bermperoglou et al. (2012), but different from our empirical findings, which is because in the model, increasing government spending implies increases in (future) taxes, reducing the disposable income and hence raising the shadow value of wealth, leading to increases in the equilibrium interest rate, which in turn reduces the private investment.

The dynamic responses of labor market variables to different government spending shocks in the benchmark simulation are summarized in Figure 3.4.2, Figure 3.4.3, Table 3.5.2, and Table 3.5.3, where we find four important observations. First, the simulated dynamic responses of the unemployment rate to different government expenditure shocks are quantitatively heterogenous. Specifically, the order of the cumulative unemployment rate multipliers are successfully reproduced in our benchmark simulation, i.e., the unemployment rate decreases by 1.9477%, 0.7063%, and 0.6079%, respectively, after a one unit shock of government wage expenditure, government investment, and government consumption expenditure. Henceforth, government wage expenditure is the more effective element in reducing the unemployment rate, which is consistent with our empirical finding. Second, the fraction of unemployed searching in the private sector increases after

be found in Appendix 3.I.

different government spending shocks, implying that providing hiring subsidy for private firms could be an effective policy to cushion the labor market. Third, both the vacancy posting and private hours worked increases after different government spending shocks, consistent with the simulation results from Bermperoglou et al. (2012). Because of the wealth effect caused by increasing different government spending, the marginal utility of private consumption increases, which decreases the disutility of working (i.e., increases the value of employment) and lowers the value of nonworking activity (i.e., decreases the value of unemployment), these two effects together raise the matching surplus, which encourages vacancy posting and labor supply. Fourth, the bargained wage decreases after different government spending shocks, which is different from our empirical findings but consistent with the simulations of Monacelli et al. (2010). This is because the value of employment increases due to the rising marginal utility of consumption, the reservation wage of workers declines. In addition, due to decreasing value of operating firms because of the rising interest rate, the wage ceiling of firms reduces. Both of these two effects contribute to the declining negotiated wages.

We also compare the time series properties of the simulated dynamic responses and estimated dynamic responses of output and the unemployment rate to different government spending shocks. From Table 3.6, we find that these properties are very similar, therefore, our model performs well even in terms of its dynamic properties.

Why Is Government Wage Expenditure Most Effective?

Both our empirical estimates and numerical simulations reveal that government wage expenditure is the more effective component in boosting output and reducing unemployment rate. We are going to explain this phenomenon by examining the features of our model and the transmission mechanisms of different government expenditure shocks.

In the standard dynamic stochastic general equilibrium model with search frictions and homogenous government spending, the impacts of different spending components on output and labor market outcomes are the same. Their propagation mechanisms are articulated by Monacelli et al. (2010). First, increasing government spending increases the marginal utility of consumption due to the wealth effect as in Galí et al. (2007), leading to decreases in the disutility of working (i.e., increases the value of employment) and the value of nonworking activity (i.e., decreases the value of unemployment), these two effects together raise the matching surplus. The rising matching surplus further encourages vacancy posting and labor supply, resulting in an increase in output and a decrease in unemployment. , i.e., the *marginal value of working channel*. Second, the equilibrium interest rate rises because of the increasing shadow value of wealth, leading to a fall in discounted values of posting vacancies and a decrease in the capital investment, which reduces the surplus of matching, leading to decreases in vacancy posting and output, i.e., the *interest rate channel* and *private capital accumulation channel*. Because of the dominant positive effect of the marginal value of working channel, increasing government spending raises output and reduces the unemployment rate.

Besides the common channels as in Monacelli et al. (2010), government wage expenditure boosts output and reduces the unemployment rate through one extra channel in our model. As the government sector is productive, increasing government wage expenditure raises government employment as well as the production of government goods, which is complementary to private goods in consumption following Cortuk and Güler (2013), thus the marginal utility of private consumption further increases, which increases the value of employment and decreases the value of unemployment, leading to a rising matching surplus, which encourages vacancy posting and labor supply, i.e., the extra *surplus channel,* which generates extra impacts of government wage expenditure on output and labor market outcomes.

Government investment exerts additional positive effects on output and the unemployment rate through two extra channels in addition to those identified by Monacelli et al. (2010). First, increasing government investment raises government physical capital, which raises matching surplus through the similar transmission mechanism as increasing government wage expenditure, resulting in more vacancy posting and labor supply, i.e., the *public physical capital accumulation channel*. Second, the rising government physical capital raises the marginal product of private capital and labor in the private sector, leading to an increase in matching surplus, which encourages vacancy posting and labor supply, i.e., the *public physical capital externality channel*, these two channels generate extra effects of government investment on output and unemployment.

The magnitude of the additional effects from the *surplus channel* for government wage expenditure and the magnitude of the additional effects from the *public physical capital accumulation channel* and the *public physical capital externality channel* depend on the structural parameter γ, i.e., the share of public physical capital in government production. If the share of public physical capital is small, the magnitude of the additional effects from the *surplus channel* for government wage expenditure exceeds the magnitude of the additional effects from two extra channels for government investment. Under our benchmark calibration, γ is set at 0.10 according to the estimates of Cubas (2010), therefore, government wage expenditure delivers the larger cumulative output and unemployment rate multipliers.

Sensitivity Analysis

The estimates for Frisch elasticity $\frac{1}{\varsigma}$ ranges from 0.1 to more than 1.0 in the empirical literature (e.g., see, Chetty et al., 2011; Peterman, 2012; and Reichling and Whalen, 2012). In our benchmark simulation, we follow Esteban-Pretel and Faraglia (2010) and Albertini et al. (2014) to adopt the value of 1.0 for ς. Here we evaluate how our benchmark results change when we allow for different values of ς, i.e., $\varsigma = 0.5$ and $\varsigma = 1.5$, through simulating the model under these parameter values.

From Figure 3.5.1, Figure 3.5.2, and Figure 3.5.3, we observe that the pattern of the simulated responses of fundamental macroeconomic variables and labor market outcomes under different values of ς are similar, although their magnitudes are different. If we reduce the Frisch utility parameter, the responses of output and labor market variables are stronger. Table 3.7 demonstrates that the order of the magnitudes of the cumulative output and unemployment rate multipliers to different shocks are the same under alternative value specifications of ς: government wage expenditure shocks deliver the largest cumulative output and unemployment rate multipliers, followed by government investment shocks, and government consumption expenditure shocks generate the smallest cumulative multipliers, consistent with our benchmark simulation results. Therefore, our benchmark simulation results are not sensitive to the specifications of values for the structural parameter ς.

3.6 The Effects of Reallocating Expenditures

We are going to deal with one of the main goals of this research, i.e., to quantitatively investigate what would have been the dynamic effects of different government expenditures on output and unemployment rate if the government reallocates the existing scarce government spending resources without changing its aggregate share in GDP.

The Evaluation Criterion and Implementation

As Spilimbergo et al. (2009) points out that the cumulative multiplier is often the most appropriate measure for the effects of government expenditures, the effectiveness increments from reallocating government expenditures are evaluated in terms of the cumulative output multipliers and the cumulative unemployment rate multipliers. According to this evaluation criteria, both our empirical analysis and benchmark simulation demonstrate that government wage expenditure is the more effective component in boosting output and cushioning the labor market. We would evaluate the results of our counterfactual experiments by examining the changes in the cumulative output multipliers and the cumulative unemployment rate multipliers.

The fundamental motivation of the counterfactual experiments is to investigate whether it is possible to improve the aggregate effectiveness of total government spending by reallocating it across different utilization purposes without changing its total share in GDP. This reallocation is implemented by changing the additional units[19] of government wage expenditure, government investment, and government consumption expenditure, respectively, without affecting the share of aggregate government spending in GDP.

As government wage expenditure is the more effective component in boosting output and reducing unemployment rate, to improve the aggregate effectiveness of total government spending, the promising reallocations of it should be increasing the more effective government wage expenditure financed by reducing the less effective components: government investment and/or government consumption expenditure. In the counterfactual experiments, we evaluate the potential efficiency gains of a 20% increase in government wage expenditures collected through four different financing schemes: (i) the scheme of lowering the other two spending components equally; (ii) the scenario of lowering the other two elements unequally; (iii) the situation of only lowering government consumption expenditure; and (iv) the experiment of only lowering government investment. The cumulative output and unemployment rate multipliers as well as their corresponding changes are computed under each scenario for effectiveness increments comparisons.

The Effects of Reallocating Government Expenditures

The simulated cumulative output multipliers are reported in the Table 3.8, where we observe that reallocation of government expenditures from the less effective components to the more effective component increases the cumulative output multiplier. In particular, the cumulative output multipliers increase by 4.9301%, 4.7681%, 5.2542%, 4.6060%, under the previously mentioned four financing schemes (i) to (iv), respectively. The reason is that the increase in output caused by the rising government wage expenditure dominates the decrease in output caused by the lowering government investment and

[19]In our benchmark calibration, the steady state shares of government wage expenditure, government investment, and government consumption expenditure in GDP is 0.0987, 0.05, 0.06, respectively. To simulate the model, the share of government wage expenditure, government investment, and government consumption expenditure are increased by *one* unit, respectively, which are the extra shares.

government consumption expenditure. Hence, reallocation of government expenditures indeed increases the effectiveness of aggregate government spending in terms of boosting output.

Table 3.8 reveals the simulated cumulative unemployment rate multipliers under the benchmark and counterfactual scenarios. Reallocating government consumption expenditure and/or government investment to government wage expenditure lower the cumulative unemployment rate multipliers. Specifically, the cumulative unemployment rate multipliers decrease by 7.9126%, 7.7623%, 8.2161%, 7.6121%, respectively, under the previously mentioned four financing schemes (i) to (iv). Therefore, reallocation of government spending does raise the effectiveness of aggregate government expenditure in terms of reducing unemployment.

Two additional findings from Table 3.8 are also important. First, the 20% increase of government wage expenditures collected by the scheme of lowering the other two spending components equally delivers relatively larger impacts on the cumulative output and unemployment rate multipliers than that financed by lowering the other two elements unequally. As in the latter scenario, the ratio of government investment and government consumption expenditure changes, the difference in the impacts on cumulative output and unemployment rate multipliers caused by the change in this ratio is named as the composition effect[20]. Second, the 20% increase of government wage expenditures financed by reducing government consumption expenditure only is the most effective redistribution scheme in terms of boosting output and reducing the unemployment rate.

Our counterfactual experiments demonstrate that by reallocating the scarce government expenditure resources appropriately, it is possible to cushion the labor market and boosting the output more effectively without causing extra fiscal burden to the government. Our results shed light on how to reallocate total government expenditure across different spending components according to their effectiveness to counter the business cycle

[20]This terminology was firstly proposed by Julen Esteban-Pretel when I was discussing my preliminary simulation results with him, I acknowledge his invaluable contributions and comments.

fluctuations of output and the unemployment rate. Moreover, our analysis also implies that: to reduce the rising government deficit, increasing taxes is not the only instrument, effectively exploration of the existing scarce government resources also helps to share the fiscal burden of government.

Robustness

In order to evaluate the robustness of our results, we perform three additional analysis. First, we consider an alternative value of inverse Frisch elasticity ς. While exiting studies such as Chetty et al. (2011) and Peterman (2012) document that Frisch elasticity $\frac{1}{\varsigma}$ ranges from 0.1 to more than 1.0, higher values of inverse Frisch elasticity would increase the marginal disutility of working, and tends to reduce the magnitudes of the cumulative output and unemployment rate multipliers. The simulation results of our model under higher values of inverse Frisch elasticity in Table 3.9.1 demonstrate that our main qualitative conclusions still hold. i.e., reallocating government resources from government consumption expenditure and/or government investment to government wage expenditure would improve the aggregate effectiveness, although the magnitudes of the increases in the cumulative output and unemployment rate multipliers are slightly higher, i.e., 20% increase in government wage expenditure financed by lowering government consumption expenditure only increases the cumulative output multiplier and the cumulative unemployment rate multiplier by 6.1213% and 9.1828%, respectively.

Second, we consider a different value of the elasticity of substitution between private goods and public goods ζ in consumption, for example, a smaller value of it. Hanemann (1991) demonstrates that ζ is important in affecting the marginal utility of private consumption, a more elastic substitution suggesting a lower value of marginal utility of consumption, leading to decreasing matching surplus and smaller cumulative unemployment and output multipliers. Our simulation results with lower values of ζ in Table 3.9.2 show that the 20% increase of government wage expenditure financed by reducing the government consumption expenditure only is the most effective reallocation scheme, the cumulative output and unemployment rate multipliers increase by 3.8139% and 7.5796%, respectively.

Finally, we examine whether our simulation results are robust to the risk aversion parameter σ or not. The empirical estimates by Gándelman and Hernández-Murillo (2014) suggest that the value of σ changes a lot, $\sigma = 1.0$ implies the specification of a log utility function. The simulation results shown in Table 3.9.3 exhibit that our main findings are robust to alternative values of risk aversion, i.e., government wage expenditure is still the more effective element in boosting output and reducing the unemployment rate, and the reallocation of the government expenditures across different spending components increases the aggregate effectiveness of total government spending in terms of increasing output and reducing unemployment.

3.7 Conclusion

Our main target in this paper has been to identify which component of government spending is more effective in boosting output and reducing unemployment, and to explain why. In addition, we also examine whether it is possible to improve the aggregate effectiveness of total government expenditure across different spending components, through evaluating the cumulative output multipliers and the cumulative unemployment multipliers.

To achieve this goal, we first perform an empirical analysis to confirm whether the dynamic effects of different government expenditures on output and labor market outcomes are heterogenous or not, as well as to find out which component is more effective in boosting output and reducing the unemployment rate. Our main empirical findings are that: first, the dynamic impacts of government wage expenditure, government investment, and government consumption expenditure on output and the unemployment rate are quantitatively heterogenous; second, government wage expenditure is the more effective component according to the estimated cumulative output multipliers and unemployment multipliers.

We then develop a directed search and matching model with heterogenous government expenditures and a productive government sector to account for these empirical findings. Calibrating the model to the U.S. economy, we show that the model can generate the empirical pattern of the dynamic responses of output and unemployment to different government spending shocks, as well as the order of the cumulative output multipliers and the cumulative unemployment rate multipliers. Employing the calibrated model, we examine the efficiency gains from reallocating government expenditures across different spending components through counterfactual experiments. Our simulation results show that reallocating government investment and/or government consumption expenditure to government wage expenditure increases the aggregate effectiveness of total government spending, the cumulative output multiplier increases and the cumulative unemployment rate multiplier decreases. Specifically, 20% increase in government wage expenditure collected through only lowering government consumption expenditure is the most effective reallocation scheme, which increases the cumulative output multiplier by 5.25% and reduces the cumulative unemployment multiplier by 8.22%, respectively. These simulation results are robust to alternative choices of important structural parameters.

The introduction of a productive government sector as well as the complementarity between private goods and government products in private consumption explains why the impacts of government wage expenditure and government investment on output and unemployment are stronger than the impacts of government consumption expenditure, as government consumption expenditure does not contribute to public production and thus it doesn't generate extra impacts on output and unemployment. Moreover, the extra impacts of government wage expenditure on output and unemployment is stronger than the extra impacts of government investment, because the share of government capital in government production is quite low. Therefore, government wage expenditure is the most effective government spending component in stimulating the economy.

This paper not only evaluates and explains how different government spending components affect output and labor market outcomes heterogeneously, but also shows the potential effectiveness increments from reallocating government expenditure across different spending components. Our analysis suggests that with the large and rising government deficit, in particular, given the difficulties in financing this huge deficit through solely collecting taxes or by sharply cutting government expenditure, if government attempts to effectively boost output and to reduce unemployment during recessions, reallocating the less effective government consumption expenditure and/or government investment to the more effective government wage expenditure can be a good alternative policy choice.

This study could be extended in a few directions. First, introducing endogenous job destruction and the worker's on-the-job search behavior as Bjelland et al. (2011) and Nagypál (2008) would be a good extension. Second, examining the role of distortionary taxes and optimal public sector policies as in Gomes (2011) would also be an interesting study. Finally, we may extend the model to incorporate heterogenous agents[21] as in Mayer et al. (2010) and examine the effects of different government spending shocks on output and labor market outcomes under more general environment.

[21]The Barro-Ricardian equivalence (e.g., Ricardo, 1820; Barro, 1974; Barro, 1979; Barro, 1989; and Feldstein, 1976) no longer holds in the presence of infinitely-lived and liquidity-constrained households, which is named as "rule-of-thumb" consumers, the question that how the presence of this type of consumers affect the impacts of fiscal policy is a very attractive topic to investigate.

3.A The Significance of Our Model Characteristics

Compared with the standard dynamic stochastic general equilibrium model with search and matching frictions, there are five new characteristics in our model: (i) Heterogenous government expenditures as in Cortuk and Güler (2013); (ii) A productive government sector originates from Cavallo (2005); (iii) The complementarity between private goods and public goods in private consumption like Bruckner and Pappa (2012); (iv) Public physical capital externality in private sector production as in Baxter and King (1993); (v) Directed search à la Quadrini and Trigari (2007) and Gomes (2011). How important is each of these features in generating our simulation results? We examine the relative importance of each of the five new features of our model in this Appendix 3.A.

The Heterogenous Government Expenditures

Without disaggregating aggregate government spending into the three heterogenous components: government wage expenditure, government investment, and government consumption expenditure, it is impossible for us to provide an answer to the question whether it is possible to improve the allocation efficiency of aggregate government spending, therefore, this characteristic is compulsory and indispensible in our model.

The Productive Government Sector

Through introducing the productive government sector employing public employment, which is determined by government wage expenditure, and public physical capital, which is directly affected by government investment, and adopting the complementarity between private goods and public goods in private consumption, we could not only characterize the different propagation mechanisms of heterogenous government spending shocks, but also explain the empirical finding that government wage expenditure is the more effective component in boosting output and reducing the unemployment rate.

Moreover, the magnitudes of the impacts of different government expenditure is directly affected by the structural parameter γ, which is interpreted as the share of public capital in production, this parameter is very important in affecting the magnitudes of the cumulative output and unemployment rate multipliers for different government expenditure shocks, we evaluate its character by looking at the changes in the cumulative multipliers with a higher value of γ, i.e., $\gamma = 0.15$. Table 3.A.1 shows that increasing the share of public physical capital in government production reduces the magnitudes of the simulated cumulative output multiplier of government wage expenditure by 6.25%, and raises the simulated cumulative unemployment rate multiplier of government wage expenditure by 8.20%, respectively. However, it affects the cumulative output and unemployment rate multipliers of government investment and government consumption expenditures only slightly. Therefore, a carefully calibrated parameter of γ is very important in generating the order of the magnitudes in cumulative output and unemployment rate multipliers in our benchmark simulation.

In addition, the productive government sector provides more insight about some of our simulation results which are different from those obtained from an otherwise standard dynamic stochastic general equilibrium model with search frictions. Our simulation shows that private consumption increases after government wage expenditure shock in Figure 3.4.1, which is different from the findings in the standard DSGE model with search frictions, see Baxter and King (1993) and Monacelli et al. (2010). By introducing the productive government sector, we can intuitively explain why this happens. As the government goods significantly increases after an increase in the government wage expenditure (the green dashed line c^g), which raises the marginal utility of private consumption and mitigates the traditional negative wealth effect, thus private consumption increases. However, the increase in government goods is not large enough to countervail the negative wealth effect after government investment shock, hence private consumption declines in response to government investment shocks.

The Complementarity Between Private Goods and Public Products

The presence of government goods in private consumption is very important in characterizing the transmission mechanisms and in explaining the main empirical findings. The degree of relative importance is captured by the structural parameter $1-\phi$, the significance of this characteristic is evaluated by plotting the simulated responses with different values of ϕ and through calculating the cumulative output and unemployment rate multipliers after shutting down this channel with $\phi = 1.0$.

From Figure 3.A.1, Figure 3.A.2, and Figure 3.A.3, we observe that as $1-\phi$ becomes smaller, the impacts of different government spending on output and labor market outcomes get weaker, because the increase in marginal utility of private consumption becomes smaller as $1-\phi$ becomes smaller, the impacts generated by the extra surplus channel are weaker. Moreover, if we remove this characteristic by setting $\phi = 1.0$, Table 3.A.2 shows that the simulated cumulative output multiplier of government wage expenditure would decrease by 43.06%, and the simulated cumulative unemployment rate multiplier of government wage expenditure would increase by 15.82%, respectively, and our model could not reproduce the magnitudes of the cumulative output and unemployment rate multipliers for the government wage expenditure anymore. Therefore, the complementarity of private goods and public products in private consumption is vital in obtaining our quantitative results.

The Public Physical Capital Externality

The introduction of public physical capital externality affects the profits of the private sector firm and hence the surplus, we evaluate its relative importance through examining the changes in the cumulative output multipliers and cumulative unemployment rate multipliers if we shut down this channel by setting $\alpha^g = 0.00$.

Table 3.A.3 shows that the simulated cumulative output multiplier of government wage expenditure would decrease by 5.58%, and the simulated cumulative unemployment rate multiplier of government wage expenditure would increase by 29.58%, respectively, and our model could not reproduce the magnitudes of the cumulative output and unemployment rate multipliers for the government wage expenditure anymore. Hence-

forth, the public physical externality feature is an indispensable element in obtaining our benchmark quantitative results.

The Directed Search

Through introducing directed search, we can disentangle the aggregate fluctuations in unemployment into the fluctuations in private sector unemployment and that in public sector unemployment after different government spending shocks, which is illustrated in Figure 3.3.2 and Table 3.5.3. First, the unemployment rate increases in the private sector and decreases in the public sector contemporaneously, which is mainly due to the behavior of directed search of the unemployment people across the two sectors. Second, the unemployment rate in the private sector and that in the public sector declines after different shocks, because of the decrease in the aggregate unemployment rate after the increase in different government spending.

Hence, our model could capture the searching behavior of unemployed people across sectors after different government spending shocks, which couldn't be observed in the random search framework. The observation provides important policy implications: to satisfy the increasing search demand of the unemployed people in the private sector, government should provide higher incentives for the firms in the private sector to post more vacancies and to hire more workers if government wants to effectively reduce the unemployment rate, such as tax deduction, or hiring subsidy discussed in Kuo and Miyamoto (2014), to mitigate the lowering probability of getting a job caused by the more tight private labor market in the labor market of the private sector.

3.B Main Tables

Table 3.1: Time Series Properties of Different Components: 1954Q1 to 2012Q4

Properties	*GWE*	*GCE*	*GIE*
Volatility	0.0037	0.0307	0.0135
Persistency	0.8665	0.4667	0.6989

Notes: (1) The volatility and persistency are computed from the detrended time series of government expenditure in levels using the Hodrick-Prescott filter with smoothing parameter 1600; (2) Here volatility is measured from their standard deviation, while persistencies are measured by their autocorrelation coefficients at lag 1.

Table 3.2.1: Estimated Fiscal Multipliers of Different Components

Horizon	Impact Multiplier			Cummulative Multiplier		
Quarter	$\frac{\Delta Y}{\Delta GWE}$	$\frac{\Delta Y}{\Delta GIE}$	$\frac{\Delta Y}{\Delta GCE}$	$\frac{\sum \Delta Y}{\sum \Delta GWE}$	$\frac{\sum \Delta Y}{\sum \Delta GIE}$	$\frac{\sum \Delta Y}{\sum \Delta GCE}$
1	0.3190	0.0723	0.0046	0.3190	0.0723	0.0046
4	0.4052	0.0884	0.0197	1.4548	0.3204	0.0351
8	0.5313	0.0890	0.0473	3.3934	0.6847	0.1936
12	0.5945	0.0671	0.0421	5.7131	0.9872	0.3771
20	0.4211	0.0303	0.0055	9.9308	1.3397	0.5421
40	-0.0453	-0.0097	0.0029	11.6646	1.4921	0.5662
Peak	0.5959	0.0925	0.0484	-	-	-
Quarter	$\frac{\Delta PCE}{\Delta GWE}$	$\frac{\Delta PCE}{\Delta GIE}$	$\frac{\Delta PCE}{\Delta GCE}$	$\frac{\sum \Delta PCE}{\sum \Delta GWE}$	$\frac{\sum \Delta PCE}{\sum \Delta GIE}$	$\frac{\sum \Delta PCE}{\sum \Delta GCE}$
1	0.1920	0.0236	0.0031	0.1920	0.0236	0.0031
4	0.3700	0.0463	0.0322	1.1380	0.1442	0.0705
8	0.5511	0.0522	0.0508	3.0979	0.3507	0.2550
12	0.6251	0.0413	0.0426	5.5224	0.5339	0.4435
20	0.4487	0.0231	0.0077	9.9495	0.7696	0.6189
40	-0.0235	-0.0060	0.0036	12.3045	0.9391	0.6704
Peak	0.6251	0.0526	0.0508	-	-	-
Quarter	$\frac{\Delta PIE}{\Delta GWE}$	$\frac{\Delta PIE}{\Delta GIE}$	$\frac{\Delta PIE}{\Delta GCE}$	$\frac{\sum \Delta PIE}{\sum \Delta GWE}$	$\frac{\sum \Delta PIE}{\sum \Delta GIE}$	$\frac{\sum \Delta PIE}{\sum \Delta GCE}$
1	0.2742	0.0474	-0.0955	0.2742	0.0474	-0.0955
4	0.5446	0.0608	0.0000	1.5799	0.1844	-0.2475
8	0.9939	0.0621	0.1411	4.9195	0.4704	0.1686
12	1.2473	-0.0022	0.1141	9.6366	0.5579	0.6984
20	0.7665	-0.0431	-0.0148	18.1515	0.2718	0.9670
40	-0.1333	-0.0293	0.0102	18.6938	-0.2522	0.8667
Peak	1.2537	0.0766	0.1457	-	-	-
Quarter	$\frac{\Delta TB3M}{\Delta GWE}$	$\frac{\Delta TB3M}{\Delta GIE}$	$\frac{\Delta TB3M}{\Delta GCE}$	$\frac{\sum \Delta TB3M}{\sum \Delta GWE}$	$\frac{\sum \Delta TB3M}{\sum \Delta GIE}$	$\frac{\sum \Delta TB3M}{\sum \Delta GCE}$
1	0.0479	0.0038	-0.0126	0.0479	0.0038	-0.0126
4	-0.1057	-0.0078	-0.0216	-0.1283	-0.0113	-0.0786
8	-0.1962	-0.0158	-0.0060	-0.8231	-0.0630	-0.1272
12	-0.1725	-0.0234	0.0049	-1.5757	-0.1459	-0.1209
20	-0.0400	-0.0263	0.0041	-2.3230	-0.3599	-0.0709
40	0.0001	0.0052	0.0000	-2.3647	-0.5258	-0.0774
Peak	-0.1990	-0.0276	0.0073	-	-	-

Notes: (1) The definitions of impact multiplier, peak multiplier, and cumulative multiplier are explained in Appendix 3.I; (2) These numbers are calculated from the estimated impulse response functions employing Matlab.

Table 3.2.2: Estimated Labor Market Multipliers of Different Components I

Horizon	Impact Multiplier			Cummulative Multiplier		
Quarter	$\frac{\Delta u}{\Delta GWE}$	$\frac{\Delta u}{\Delta GIE}$	$\frac{\Delta u}{\Delta GCE}$	$\frac{\sum \Delta u}{\sum \Delta GWE}$	$\frac{\sum \Delta u}{\sum \Delta GIE}$	$\frac{\sum \Delta u}{\sum \Delta GCE}$
1	-0.0367	-0.0039	0.0058	-0.0367	-0.0039	0.0058
4	-0.0962	-0.0279	0.0023	-0.2645	-0.0647	0.0239
8	-0.1636	-0.0393	-0.0141	-0.8271	-0.2125	-0.0115
12	-0.2063	-0.0327	-0.0156	-1.5958	-0.3570	-0.0759
20	-0.1535	-0.0130	-0.0000	-3.1297	-0.5261	-0.1325
40	0.0338	0.0069	0.0001	-3.4822	-0.5465	-0.1066
Peak	-0.2116	-0.0393	-0.0166	-	-	-
Quarter	$\frac{\Delta VR}{\Delta GWE}$	$\frac{\Delta VR}{\Delta GIE}$	$\frac{\Delta VR}{\Delta GCE}$	$\frac{\sum \Delta VR}{\sum \Delta GWE}$	$\frac{\sum \Delta VR}{\sum \Delta GIE}$	$\frac{\sum \Delta VR}{\sum \Delta GCE}$
1	0.1655	0.0732	-0.0506	0.8024	0.0732	-0.0506
4	0.2223	0.0876	0.0071	1.9746	0.3179	-0.1488
8	0.6354	0.0412	0.1534	4.8241	0.5892	0.2873
12	1.0005	-0.0559	0.1496	11.2897	0.5077	0.9330
20	0.5813	-0.1252	-0.0180	28.3390	-0.4016	1.3473
40	-0.3624	0.0205	-0.0088	19.1821	-1.4928	0.9904
Peak	1.0467	0.0886	0.1679	-	-	-
Quarter	$\frac{\Delta PHO}{\Delta GWE}$	$\frac{\Delta PHO}{\Delta GIE}$	$\frac{\Delta PHO}{\Delta GCE}$	$\frac{\sum \Delta PHO}{\sum \Delta GWE}$	$\frac{\sum \Delta PHO}{\sum \Delta GIE}$	$\frac{\sum \Delta PHO}{\sum \Delta GCE}$
1	0.1720	0.0312	-0.0149	0.1720	0.0312	-0.0149
4	0.2425	0.0435	-0.0071	0.8251	0.1488	-0.0599
8	0.3599	0.0400	0.0317	2.0876	0.3263	0.0152
12	0.4507	0.0109	0.0391	3.7756	0.4164	0.1715
20	0.3390	-0.0337	0.0053	7.1515	0.2736	0.3386
40	-0.0910	-0.0309	0.0036	7.7321	-0.4580	0.3196
Peak	0.4596	0.0467	0.0405	-	-	-

Notes: (1) The definitions of impact multiplier, peak multiplier, and cumulative multiplier are explained in Appendix 3.I; (2) These numbers are calculated from the estimated impulse response functions employing Matlab.

Table 3.2.3: Estimated Labor Market Multipliers of Different Components II

Horizon	Impact Multiplier			Cummulative Multiplier		
Quarter	$\frac{\Delta RPW}{\Delta GWE}$	$\frac{\Delta RPW}{\Delta GIE}$	$\frac{\Delta RPW}{\Delta GCE}$	$\frac{\sum \Delta RPW}{\sum \Delta GWE}$	$\frac{\sum \Delta RPW}{\sum \Delta GIE}$	$\frac{\sum \Delta RPW}{\sum \Delta GCE}$
1	-0.0382	-0.0239	-0.0000	-0.0382	-0.0239	-0.0000
4	-0.0170	0.0000	0.0021	-0.1249	-0.0438	0.0001
8	0.0615	0.0262	0.0085	-0.0013	0.0230	0.0255
12	0.1232	0.0427	0.0104	0.4071	0.1731	0.0662
20	0.1434	0.0507	0.0017	1.5758	0.5658	0.1136
40	0.0054	0.0143	-0.0000	2.7453	1.2767	0.0977
Peak	0.1511	0.0510	0.0105	-	-	-
Quarter	$\frac{\Delta JFP}{\Delta GWE}$	$\frac{\Delta JFP}{\Delta GIE}$	$\frac{\Delta JFP}{\Delta GCE}$	$\frac{\sum \Delta JFP}{\sum \Delta GWE}$	$\frac{\sum \Delta JFP}{\sum \Delta GIE}$	$\frac{\sum \Delta JFP}{\sum \Delta GCE}$
1	0.2942	0.0488	-0.0407	0.2942	0.0488	-0.0407
4	0.4611	0.1104	-0.0019	1.5614	0.3140	-0.0785
8	0.6479	0.1456	0.0615	3.8552	0.8714	0.0823
12	0.7905	0.1123	0.0670	6.8405	1.3813	0.3607
20	0.5843	0.0384	0.0015	12.7230	1.9159	0.6078
40	-0.1497	-0.0210	0.0033	13.5095	1.9819	0.4941
Peak	0.8137	0.1456	0.0716	-	-	-
Quarter	$\frac{\Delta EEP}{\Delta GWE}$	$\frac{\Delta EEP}{\Delta GIE}$	$\frac{\Delta EEP}{\Delta GCE}$	$\frac{\sum \Delta EEP}{\sum \Delta GWE}$	$\frac{\sum \Delta EEP}{\sum \Delta GIE}$	$\frac{\sum \Delta EEP}{\sum \Delta GCE}$
1	-0.0223	-0.0031	0.0014	-0.0223	-0.0031	0.0014
4	-0.0232	-0.0096	-0.0020	-0.0873	-0.0284	-0.0001
8	-0.0296	-0.0093	-0.0018	-0.1975	-0.0671	-0.0094
12	-0.0289	-0.0077	-0.0001	-0.3168	-0.1004	-0.0134
20	-0.0117	-0.0044	-0.0001	-0.4788	-0.1469	-0.0105
40	0.0047	0.0013	0.0000	-0.4422	-0.1646	-0.0059
Peak	-0.0304	-0.0099	-0.0023	-	-	-

Notes: (1) The definitions of impact multiplier, peak multiplier, and cumulative multiplier are explained in Appendix 3.I; (2) These numbers are calculated from the estimated impulse response functions employing Matlab.

Table 3.3.1: Parameter Values: Exogenously Assigned

Parameters	Notation	Value	Source
Private depreciation rate	δ^p	0.025	Monacelli et al. (2010)
Private consumption share	ϕ	0.70	Bruckner and Pappa (2012)
Consumption substitutability	ζ	0.40	Bruckner and Pappa (2012)
Relative risk aversion	σ	2.00	Bruckner and Pappa (2012)
Frisch elasticity inverse	ς	1.00	Reichling and Whalen (2012)
Public capital elasticity	α^g	0.05	Baxter and King (1993)
Public depreciation rate	δ^g	0.02	Baxter and King (1993)

Table 3.3.2: Parameter Values: Data Moment

Parameters	Notation	Value	Source
Discount factor	β	0.99	Data moment
Private capital share	α^p	0.33	Data moment
Private matching elasticity	μ^p	0.50	Estimation
Private bargaining power	ξ	0.50	μ^p=ξ
Public matching elasticity	μ^g	0.20	Estimation
Public separation rate	λ^g	0.03	Data moment
Public wage premium	π^g	0.02	Data moment
Private technology shock	a^p	1.00	Normalization
Public technology shock	a^g	1.00	Normalization
Public capital share	γ	0.10	Share of governemnt capital
Private vacancy cost	ι^p	2.00	The share of recruitment cost
Public vacancy cost	ι^g	1.10	The share of recruitment cost
Public hours autocorr.	ρ_{hg}	0.9839	Data moment
Public investment autocorr.	ρ_{Ig}	0.9080	Data moment
Public consumption autocorr.	ρ_{gg}	0.8969	Data moment
Public hours std. dev.	σ^{hg}	0.0065	Data moment
Public investment std. dev.	σ^{Ig}	0.0030	Data moment
Public consumption std. dev.	σ^{gg}	0.0045	Data moment

Table 3.3.3: Parameter Values: Endogenously Calibrated

Parameters	Notation	Value	Target
Private matching efficiency	η^p	1.7756	Private unemployed duration
Public matching efficiency	η^g	1.2766	Public unemployed duration
Private separation rate	λ^p	0.0412	Share of private employment
Public vacancy	v^g	0.0023	Share of public employment
Disutility of working	ψ	14.0305	Private working hours

Table 3.4.1: Steady State Model Solutions: Targeted Variables

Variables	Notation	Model	Data
Unemployment rate	u	0.0600	0.0600
Private working share	n^p	0.8000	0.8000
Public working share	n^g	0.1400	0.1400
Private vacancy duration	$\frac{1}{q^p}$	0.2200	0.2200
Public vacancy duration	$\frac{1}{q^g}$	0.5600	0.5600
Private hours worked	h^p	0.3300	0.3300

Table 3.4.2: Steady State Model Predictions: Validation

Variables	Notation	Model	Data
Share of recruitment cost[a]	$\frac{\sum \iota^i v^i}{\sum w^i n^i h^i}$	0.0264	0.0250
Unemployed searching public jobs[a]	s	0.2167	0.2000
Private unemployment rate[a]	u^p	0.0470	0.0480
Public unemployment rate[a]	u^g	0.0130	0.0120
Ratio of public/private values[b]	$\frac{\Delta^g}{\Delta^p}$	2.1693	2.6900
Ratio of public/private wages	$\frac{w^g}{w^p}$	1.0200	[1.00,1.10]
Share of government expenditure	$\frac{w^g n^g h^g + I^g + g^g}{Y}$	0.2181	0.2103
Share of private investment	$\frac{I^p}{Y}$	0.2350	0.1729
Share of private consumption	$\frac{c^p}{Y}$	0.5030	0.6301

Notes: (10-1) a *indicates that the data is from the model solutions of Burgert and Gomes (2011); (10-2)* b *indicates that the data is from the model solutions of Gomes (2011); (10-3) The data is the average of the corresponding time series from 1954Q1 to 2012Q4.*

Table 3.5.1: Simulated Output Multipliers of Different Components

Horizon	Impact Multiplier			Cummulative Multiplier		
Quarter	$\frac{\Delta Y}{\Delta GWE}$	$\frac{\Delta Y}{\Delta GIE}$	$\frac{\Delta Y}{\Delta GCE}$	$\frac{\sum\Delta Y}{\sum\Delta GWE}$	$\frac{\sum\Delta Y}{\sum\Delta GIE}$	$\frac{\sum\Delta Y}{\sum\Delta GCE}$
1	0.4153	0.3072	0.2873	0.4153	0.3072	0.2873
4	0.4038	0.2211	0.1944	1.6454	1.0546	0.9597
8	0.3773	0.1364	0.1077	3.1936	1.7162	1.5079
12	0.3526	0.0811	0.0542	4.6404	2.1161	1.7969
20	0.3082	0.0229	0.0028	7.2569	2.4687	1.9643
40	0.2210	-0.0072	-0.0157	12.4549	2.4771	1.7114
Peak	0.4159	0.3072	0.2873	-	-	-
Quarter	$\frac{\Delta PCE}{\Delta GWE}$	$\frac{\Delta PCE}{\Delta GIE}$	$\frac{\Delta PCE}{\Delta GCE}$	$\frac{\sum\Delta PCE}{\sum\Delta GWE}$	$\frac{\sum\Delta PCE}{\sum\Delta GIE}$	$\frac{\sum\Delta PCE}{\sum\Delta GCE}$
1	0.1548	-0.2512	-0.2349	0.1548	-0.2512	-0.2349
4	0.1446	-0.2357	-0.2211	0.6026	-0.9744	-0.9127
8	0.1365	-0.2127	-0.2001	1.1633	-1.8602	-1.7452
12	0.1273	-0.1890	-0.1782	1.6860	-2.6518	-2.4908
20	0.1113	-0.1448	-0.1372	2.6306	-3.9610	-3.7283
40	0.0809	-0.0674	-0.0660	4.5181	-5.9638	-5.6498
Peak	0.1548	-0.2512	-0.2349	-	-	-
Quarter	$\frac{\Delta PIE}{\Delta GWE}$	$\frac{\Delta PIE}{\Delta GIE}$	$\frac{\Delta PIE}{\Delta GCE}$	$\frac{\sum\Delta PIE}{\sum\Delta GWE}$	$\frac{\sum\Delta PIE}{\sum\Delta GIE}$	$\frac{\sum\Delta PIE}{\sum\Delta GCE}$
1	-0.0817	-2.3565	-2.4802	-0.0817	-2.3565	-2.4802
4	-0.0057	-1.6472	-1.6789	-0.1204	-7.9320	-8.2325
8	0.0013	-1.0214	-0.9929	-0.1245	-12.8748	-13.1341
12	0.0063	-0.6120	-0.5626	-0.1066	-15.8780	-15.9667
20	0.0130	-0.1711	-0.1329	-0.0239	-18.5314	-18.2596
40	0.0182	-0.0702	0.0677	0.3100	-18.4087	-17.8670
Peak	-0.0817	-2.3565	-2.4802	-	-	-
Quarter	$\frac{\Delta TB3M}{\Delta GWE}$	$\frac{\Delta TB3M}{\Delta GIE}$	$\frac{\Delta TB3M}{\Delta GCE}$	$\frac{\sum\Delta TB3M}{\sum\Delta GWE}$	$\frac{\sum\Delta TB3M}{\sum\Delta GIE}$	$\frac{\sum\Delta TB3M}{\sum\Delta GCE}$
1	0.4153	0.3072	0.2873	0.4153	0.3072	0.2873
4	0.4065	0.3741	0.3539	1.6527	1.3758	1.2957
8	0.3800	0.4082	0.3858	3.2122	2.9708	2.8049
12	0.3547	0.4086	0.3837	4.6686	4.6125	4.3507
20	0.3082	0.3598	0.3329	7.2934	7.6893	7.2165
40	0.2144	0.1944	0.1763	12.4210	13.0946	12.1576
Peak	0.4179	0.3072	0.3879	-	-	-

Notes: (1) The definitions of impact multiplier, peak multiplier, and cumulative multiplier are explained in Appendix 3.I; (2) These numbers are calculated from the simulated impulse response functions employing Matlab.

Table 3.5.2: Simulated Labor Market Multipliers of Different Components I

Horizon	Impact Multiplier			Cummulative Multiplier		
Quarter	$\frac{\Delta u}{\Delta GWE}$	$\frac{\Delta u}{\Delta GIE}$	$\frac{\Delta u}{\Delta GCE}$	$\frac{\sum \Delta u}{\sum \Delta GWE}$	$\frac{\sum \Delta u}{\sum \Delta GIE}$	$\frac{\sum \Delta u}{\sum \Delta GCE}$
1	0.0000	-0.0000	0.0000	0.0000	-0.0000	0.0000
4	-0.2922	-0.1170	-0.1027	-0.8235	-0.3616	-0.3238
8	-0.2733	-0.0696	-0.0544	-1.9477	-0.7063	-0.6079
12	-0.2536	-0.0382	-0.0241	-2.9911	-0.9019	-0.7450
20	-0.2187	-0.0060	0.0041	-4.8590	-1.0427	-0.7906
40	-0.1525	0.0081	0.0120	-8.4947	-0.9392	-0.5617
Peak	-0.2922	-0.1273	-0.1141	-	-	-
Quarter	$\frac{\Delta VR}{\Delta GWE}$	$\frac{\Delta VR}{\Delta GIE}$	$\frac{\Delta VR}{\Delta GCE}$	$\frac{\sum \Delta VR}{\sum \Delta GWE}$	$\frac{\sum \Delta VR}{\sum \Delta GIE}$	$\frac{\sum \Delta VR}{\sum \Delta GCE}$
1	0.6221	0.3283	0.2993	0.6221	0.3283	0.2993
4	0.2164	0.0723	0.0563	1.3722	0.6312	0.5514
8	0.1984	0.0348	0.0199	2.1884	0.8192	0.6778
12	0.1849	0.0125	-0.0004	2.9478	0.8993	0.7029
20	0.1607	-0.0084	-0.0173	4.3155	0.8901	0.6090
40	0.1141	-0.0122	-0.0157	7.0144	0.6313	0.2402
Peak	0.6221	0.3283	0.2993	-	-	-
Quarter	$\frac{\Delta PHO}{\Delta GWE}$	$\frac{\Delta PHO}{\Delta GIE}$	$\frac{\Delta PHO}{\Delta GCE}$	$\frac{\sum \Delta PHO}{\sum \Delta GWE}$	$\frac{\sum \Delta PHO}{\sum \Delta GIE}$	$\frac{\sum \Delta PHO}{\sum \Delta GCE}$
1	0.6199	0.4586	0.4288	0.6199	0.4586	0.4288
4	0.5812	0.3925	0.3609	2.3974	1.6973	1.5740
8	0.5401	0.3237	0.2927	4.6185	3.0906	2.8415
12	0.5019	0.2685	0.2400	6.6826	4.2438	3.8767
20	0.4337	0.1870	0.1655	10.3842	6.0033	5.4395
40	0.3017	0.0788	0.0709	17.5893	8.4450	7.6098
Peak	0.6199	0.4586	0.4288	-	-	-

Notes: (1) The definitions of impact multiplier, peak multiplier, and cumulative multiplier are explained in Appendix 3.I; (2) These numbers are calculated from the simulated impulse response functions employing Matlab.

Table 3.5.3: Simulated Labor Market Multipliers of Different Components II

Horizon	Impact Multiplier			Cummulative Multiplier		
Quarter	$\frac{\Delta RPW}{\Delta GWE}$	$\frac{\Delta RPW}{\Delta GIE}$	$\frac{\Delta RPW}{\Delta GCE}$	$\frac{\sum \Delta RPW}{\sum \Delta GWE}$	$\frac{\sum \Delta RPW}{\sum \Delta GIE}$	$\frac{\sum \Delta RPW}{\sum \Delta GCE}$
1	-0.2115	-0.1645	-0.1553	-0.2115	-0.1645	-0.1553
4	-0.2048	-0.1919	-0.1862	-0.8353	-0.7182	-0.6887
8	-0.1914	-0.2044	-0.2007	-1.6208	-1.5232	-1.4765
12	-0.1787	-0.2016	-0.1985	-2.3544	-2.3375	-2.2776
20	-0.1552	-0.1742	-0.1712	-3.6765	-3.8390	-3.7547
40	-0.1079	-0.0906	-0.0903	-6.2587	-6.4092	-6.2898
Peak	-0.2115	-0.2048	-0.2014	-	-	-
Quarter	$\frac{\Delta PUR}{\Delta GWE}$	$\frac{\Delta PUR}{\Delta GIE}$	$\frac{\Delta PUR}{\Delta GCE}$	$\frac{\sum \Delta PUR}{\sum \Delta GWE}$	$\frac{\sum \Delta PUR}{\sum \Delta GIE}$	$\frac{\sum \Delta PUR}{\sum \Delta GCE}$
1	0.2372	0.0793	0.0727	0.2372	0.0793	0.0727
4	-0.1446	-0.0886	-0.0780	-0.1175	-0.1814	-0.1620
8	-0.1358	-0.0477	-0.0358	-0.6775	-0.4298	-0.3637
12	-0.1249	-0.0208	-0.0097	-1.1932	-0.5494	-0.4374
20	-0.1060	0.0053	0.0132	-2.1052	-0.5807	-0.3936
40	-0.0716	0.0125	0.0155	-3.8393	-0.3364	-0.0522
Peak	-0.1446	-0.0956	-0.0863	-	-	-
Quarter	$\frac{\Delta GUR}{\Delta GWE}$	$\frac{\Delta GUR}{\Delta GIE}$	$\frac{\Delta GUR}{\Delta GCE}$	$\frac{\sum \Delta GUR}{\sum \Delta GWE}$	$\frac{\sum \Delta GUR}{\sum \Delta GIE}$	$\frac{\sum \Delta GUR}{\sum \Delta GCE}$
1	-0.8878	-0.2968	-0.2722	-0.8878	-0.2968	-0.2722
4	-0.8448	-0.2231	-0.1951	-3.4664	-1.0359	-0.9298
8	-0.7879	-0.1517	-0.1238	-6.7021	-1.7411	-1.5222
12	-0.7351	-0.1033	-0.0780	-9.7206	-2.2209	-1.8966
20	-0.6403	-0.0483	-0.0299	-15.1660	-2.7716	-2.2764
40	-0.4552	-0.0083	-0.0011	-25.9195	-3.1956	-2.4685
Peak	-0.8878	-0.2968	-0.2722	-	-	-

Notes: (1) The definitions of impact multiplier, peak multiplier, and cumulative multiplier are explained in Appendix 3.I; (2) These numbers are calculated from the simulated impulse response functions employing Matlab.

Table 3.6: Properties of Estimated and Simulated Output Multipliers

Property	Estimated Multipliers			Simulated Multipliers		
	$\frac{\Delta Y}{\Delta GWE}$	$\frac{\Delta Y}{\Delta GIE}$	$\frac{\Delta Y}{\Delta GCE}$	$\frac{\Delta Y}{\Delta GWE}$	$\frac{\Delta Y}{\sum \Delta GIE}$	$\frac{\Delta Y}{\sum \Delta GCE}$
Aut. Cor.	0.9673	0.9578	0.9667	0.9296	0.8823	0.8717
Std. Err.	0.2015	0.0345	0.0176	0.0604	0.0877	0.0831
	$\frac{\Delta u}{\Delta GWE}$	$\frac{\Delta u}{\Delta GIE}$	$\frac{\Delta u}{\Delta GCE}$	$\frac{\Delta u}{\Delta GWE}$	$\frac{\Delta u}{\Delta GIE}$	$\frac{\Delta u}{\Delta GCE}$
Aut. Cor.	0.9667	0.9662	0.9409	0.5270	0.8744	0.8805
Std. Err.	0.2057	0.0325	0.0168	0.0547	0.0410	0.0380

Notes: (1) These time series characteristics are computed from the estimated and simulated impulse response functions; (2) These numbers are calculated employing the built-in functions of Matlab.

Table 3.7: Sensitivity Analysis for Different Values of Inverse Frisch Elasticity ς

Counterfactuals	Estimated/Simulated Cumulative Multiplier		
	$\frac{\sum \Delta Y}{\sum \Delta GWE}$	$\frac{\sum \Delta Y}{\sum \Delta GIE}$	$\frac{\sum \Delta Y}{\sum \Delta GCE}$
Benchmark (1.0)	3.1936	1.7162	1.5079
Lower Value (0.5)	4.1172	2.4909	2.2286
Higher Value (1.5)	2.6264	1.2722	1.0970
	$\frac{\sum \Delta u}{\sum \Delta GWE}$	$\frac{\sum \Delta u}{\sum \Delta GIE}$	$\frac{\sum \Delta u}{\sum \Delta GCE}$
Benchmark (1.0)	-1.9477	-0.7063	-0.6079
Lower Value (0.5)	-1.8050	-0.7395	-0.6412
Higher Value (1.5)	-1.9356	-0.6157	-0.5240

Notes: (1) The definition of cumulative multiplier is explained in Appendix 3.I; (2) These numbers are calculated from the estimated and simulated impulse response functions employing Matlab.

Table 3.A.1: Counterfactual Results Under Higher Public Capital Share

Counterfactuals	Estimated/Simulated Cumulative Multiplier		
	$\frac{\sum \Delta Y}{\sum \Delta GWE}$	$\frac{\sum \Delta Y}{\sum \Delta GIE}$	$\frac{\sum \Delta Y}{\sum \Delta GCE}$
Benchmark	3.1936	1.7162	1.5079
Higher γ	2.9941	1.6878	1.4796
Changes Percent	$\downarrow$ 6.25%	$\downarrow$ 1.65%	$\downarrow$ 1.88%
	$\frac{\sum \Delta u}{\sum \Delta GWE}$	$\frac{\sum \Delta u}{\sum \Delta GIE}$	$\frac{\sum \Delta u}{\sum \Delta GCE}$
Benchmark	-1.9477	-0.7063	-0.6079
Higher γ	-1.7884	-0.7051	-0.6058
Changes Percent	$\uparrow$ 8.20%	$\uparrow$ 0.17%	$\uparrow$ 0.35%

Notes: (1) The definition of cumulative multiplier is explained in Appendix 3.I; (2) These numbers are calculated from the estimated and simulated impulse response functions employing Matlab; (3) The $\uparrow$ indicates increase for cumulative output multipliers, while $\downarrow$ implies decreases for cumulative unemployment rate multipliers, as they are negative, decreasing suggests that the impact become stronger; (4) The counterfactuals of higher γ are calculated with $\gamma = 0.15$.

Table 3.8: Counterfactual Results on Cumulative Output and Unemployment Rate Multipliers

Counterfactuals	Estimated/Simulated Cumulative Multiplier			Total	Change %	Preference
	$\frac{\sum \Delta Y}{\sum \Delta GWE}$	$\frac{\sum \Delta Y}{\sum \Delta GIE}$	$\frac{\sum \Delta Y}{\sum \Delta GCE}$			
Benchmark	3.1936	1.7162	1.5079	6.4177		
Equally Reducing	3.8324	1.5446	1.3571	6.7341	$\uparrow$4.9301	2
Unequally Reducing	3.8324	1.4588	1.4325	6.7237	$\uparrow$4.7681	3
Reducing GCE	3.8324	1.7162	1.2063	6.7549	$\uparrow$5.2542	1
Reducing GIE	3.8324	1.3730	1.5079	6.7133	$\uparrow$4.6060	4
	$\frac{\sum \Delta u}{\sum \Delta GWE}$	$\frac{\sum \Delta u}{\sum \Delta GIE}$	$\frac{\sum \Delta u}{\sum \Delta GCE}$			
Benchmark	-1.9477	-0.7063	-0.6079	-3.2619		
Equally Reducing	-2.3373	-0.6356	-0.5471	-3.5200	$\downarrow$7.9126	2
Unequally Reducing	-2.3373	-0.6003	-0.5775	-3.5151	$\downarrow$7.7623	3
Reducing GCE	-2.3373	-0.7063	-0.4863	-3.5299	$\downarrow$8.2161	1
Reducing GIE	-2.3373	-0.5650	-0.6079	-3.5102	$\downarrow$7.6121	4

Notes: (1) The definition of cumulative multiplier is explained in Appendix 3.I; (2) These numbers are calculated from the estimated and simulated impulse response functions employing Matlab; (3) The Equally Reducing, Unequally Reducing, Reducing GCE, Reducing GIE correspond to the dour different financing schemes explained in Section 3.6; (4) The $\uparrow$ indicates increase for cumulative output multipliers, while $\downarrow$ implies decreases for cumulative unemployment rate multipliers, as they are negative, decreasing suggests that the impact become stronger; (5) Preference reveals the policy priorities over the four financing schemes according to our simulation results.

Table 3.9.1: Cumulative Output and Unemployment Rate Multipliers: Robustness for Higher ς

Counterfactuals	Estimated/Simulated Cumulative Multiplier			Total	Change %	Preference
	$\frac{\sum \Delta Y}{\sum \Delta GWE}$	$\frac{\sum \Delta Y}{\sum \Delta GIE}$	$\frac{\sum \Delta Y}{\sum \Delta GCE}$			
Benchmark	3.1936	1.7162	1.5079	6.4177		
Higher ς	2.6264	1.2722	1.0970	4.9956		
Equally Reducing	3.1516	1.1450	0.9873	5.2839	↑5.7710	2
Unequally Reducing	3.1516	1.0814	1.0421	5.2751	↑5.5949	3
Reducing GCE	3.1516	1.2722	0.8776	5.3014	↑6.1213	1
Reducing GIE	3.1516	1.0178	1.0970	5.2664	↑5.4207	4
	$\frac{\sum \Delta u}{\sum \Delta GWE}$	$\frac{\sum \Delta u}{\sum \Delta GIE}$	$\frac{\sum \Delta u}{\sum \Delta GCE}$			
Benchmark	-1.9477	-0.7063	-0.6079	-3.2619		
Higher ς	-1.9356	-0.6157	-0.5240	-3.0753		
Equally Reducing	-2.3228	-0.5541	-0.4716	-3.3485	↓8.8834	2
Unequally Reducing	-2.3228	-0.5233	-0.4978	-3.3439	↓8.7341	3
Reducing GCE	-2.3228	-0.6157	-0.4192	-3.3577	↓9.1828	1
Reduicing GIE	-2.3228	-0.4952	-0.5240	-3.3420	↓8.6723	4

Notes: (1) The definition of cumulative multiplier is explained in Appendix 3.1; (2) These numbers are calculated from the estimated and simulated impulse response functions employing Matlab; (3) The Equally Reducing, Unequally Reducing, Reducing GCE, Reducing GIE correspond to the dour different financing schemes explained in Section 3.6; (4) The ↑ indicates increase for cumulative output multipliers, while ↓ implies decreases for cumulative unemployment rate multipliers, as they are negative, decreasing suggests that the impact become stronger; (5) Preference indicates the policy priorities over the four financing schemes according to our simulation results; (6) The counterfactuals of different financing schemes are calculated with $\varsigma = 1.50$.

Table 3.9.2: Cumulative Output and Unemployment Rate Multipliers: Robustness for Higher ζ

Counterfactuals	Estimated/Simulated Cumulative Multiplier			Total	Change %	Preference
	$\frac{\sum \Delta Y}{\sum \Delta GWE}$	$\frac{\sum \Delta Y}{\sum \Delta GIE}$	$\frac{\sum \Delta Y}{\sum \Delta GCE}$			
Benchmark	3.1936	1.7162	1.5079	6.4177		
Higher ζ	2.5631	1.6768	1.4734	5.7133		
Equally Reducing	3.0757	1.5091	1.3260	5.9108	↑3.4568	2
Unequally Reducing	3.0757	1.4253	1.3997	5.9007	↑3.2801	3
Reducing GCE	3.0757	1.6768	1.1787	5.9312	↑3.8139	1
Reducing GIE	3.0757	1.3414	1.4734	5.8905	↑3.1015	4
	$\frac{\sum \Delta u}{\sum \Delta GWE}$	$\frac{\sum \Delta u}{\sum \Delta GIE}$	$\frac{\sum \Delta u}{\sum \Delta GCE}$			
Benchmark	-1.9477	-0.7063	-0.6079	-3.2619		
Higher ζ	-1.7245	-0.6844	-0.5886	-2.9975		
Equally Reducing	-2.0694	-0.6159	-0.5297	-3.2150	↓7.2560	2
Unequally Reducing	-2.0694	-0.5817	-0.5591	-3.2102	↓7.0960	3
Reducing GCE	-2.0694	-0.6844	-0.4709	-3.2247	↓7.5796	1
Reduicing GIE	-2.0694	-0.5475	-0.5886	-3.2055	↓6.9391	4

Notes: (1) The definition of cumulative multiplier is explained in Appendix 3.1; (2) These numbers are calculated from the estimated and simulated impulse response functions employing Matlab; (3) The Equally Reducing, Unequally Reducing, Reducing GCE, Reducing GIE correspond to the dour different financing schemes explained in Section 3.6; (4) The ↑ indicates increase for cumulative output multipliers, while ↓ implies decreases for cumulative unemployment rate multipliers, as they are negative, decreasing suggests that the impact become stronger; (5) Preference reveals the policy priorities over the four financing schemes according to our simulation results; (6) The counterfactuals of different financing schemes are calculated with $\zeta = 0.44$.

Table 3.9.3: Cumulative Output and Unemployment Rate Multipliers: Robustness for Alternative σ

Counterfactuals	Estimated/Simulated Cumulative Multiplier			Total	Change %	Preference
	$\frac{\sum \Delta Y}{\sum \Delta GWE}$	$\frac{\sum \Delta Y}{\sum \Delta GIE}$	$\frac{\sum \Delta Y}{\sum \Delta GCE}$			
Benchmark	3.1936	1.7162	1.5079	6.4177		
Alternative σ	5.9500	1.5823	1.3733	8.9056		
Equally Reducing	7.1400	1.4241	1.2360	9.8001	↑10.0442	2
Unequally Reducing	7.1400	1.3449	1.3046	9.7895	↑9.9252	3
Reducing GCE	7.1400	1.5823	1.0986	9.8209	↑10.2778	1
Reducing GIE	7.1400	1.2658	1.3733	9.7791	↑9.8084	4
	$\frac{\sum \Delta u}{\sum \Delta GWE}$	$\frac{\sum \Delta u}{\sum \Delta GIE}$	$\frac{\sum \Delta u}{\sum \Delta GCE}$			
Benchmark	-1.9477	-0.7063	-0.6079	-3.2619		
Alternative σ	-2.8282	-0.6951	-0.5922	-4.1155		
Equally Reducing	-3.3938	-0.6256	-0.5329	-4.5523	↓10.6135	2
Unequally Reducing	-3.3938	-0.5908	-0.5625	-4.5471	↓10.4872	3
Reducing GCE	-3.3938	-0.6951	-0.4737	-4.5626	↓10.8638	1
Reduicing GIE	-3.3938	-0.5561	-0.5922	-4.5421	↓10.3657	4

Notes: (1) The definition of cumulative multiplier is explained in Appendix 3.I; (2) These numbers are calculated from the estimated and simulated impulse response functions employing Matlab; (3) The Equally Reducing, Unequally Reducing, Reducing GCE, Reducing GIE correspond to the dour different financing schemes explained in Section 3.6; (4) The ↑ indicates increase for cumulative output multipliers, while ↓ implies decreases for cumulative unemployment rate multipliers, as they are negative, decreasing suggests that the impact become stronger; (5) Preference reveals the policy priorities over the four financing schemes according to our simulation results; (6) The counterfactuals of different financing schemes are calculated with $\sigma = 2.00$.

Table 3.A.2: Counterfactual Results Shutting Down The Surplus Channel

Counterfactuals	Estimated/Simulated Cumulative Multiplier		
	$\frac{\sum \Delta Y}{\sum \Delta GWE}$	$\frac{\sum \Delta Y}{\sum \Delta GIE}$	$\frac{\sum \Delta Y}{\sum \Delta GCE}$
Benchmark	3.1936	1.7162	1.5079
Shutting Down	1.8183	1.6296	1.4320
Changes Percent	$\downarrow$ 43.06%	$\downarrow$ 5.05%	$\downarrow$ 5.03%
	$\frac{\sum \Delta u}{\sum \Delta GWE}$	$\frac{\sum \Delta u}{\sum \Delta GIE}$	$\frac{\sum \Delta u}{\sum \Delta GCE}$
Benchmark	-1.9477	-0.7063	-0.6079
Shutting Down	-1.4682	-0.6582	-0.5655
Changes Percent	$\uparrow$ 15.82%	$\uparrow$ 6.81%	$\uparrow$ 6.97%

Notes: (1) The definition of cumulative multiplier is explained in Appendix 3.I; (2) These numbers are calculated from the estimated and simulated impulse response functions employing Matlab; (3) The $\uparrow$ indicates increase for cumulative output multipliers, while $\downarrow$ implies decreases for cumulative unemployment rate multipliers, as they are negative, decreasing suggests that the impact become stronger; (4) The counterfactuals of shutting down the surplus channel are calculated with $\phi = 1.00$.

Table 3.A.3: Counterfactual Results Shutting Down The Externality Channel

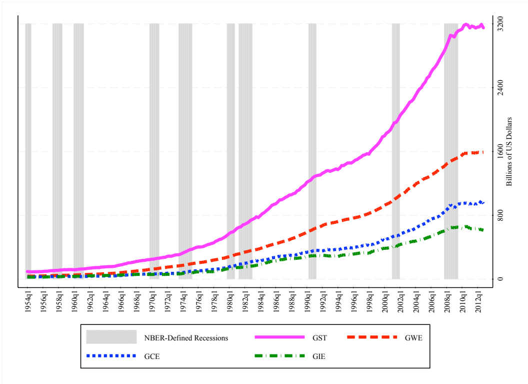
Counterfactuals	Estimated/Simulated Cumulative Multiplier		
	$\frac{\sum \Delta Y}{\sum \Delta GWE}$	$\frac{\sum \Delta Y}{\sum \Delta GIE}$	$\frac{\sum \Delta Y}{\sum \Delta GCE}$
Benchmark	3.1936	1.7162	1.5079
Shutting Down	3.0161	2.1088	1.8549
Changes Percent	↓ 5.58%	↑ 22.88%	↑ 23.01%
	$\frac{\sum \Delta u}{\sum \Delta GWE}$	$\frac{\sum \Delta u}{\sum \Delta GIE}$	$\frac{\sum \Delta u}{\sum \Delta GCE}$
Benchmark	-1.9477	-0.7063	-0.6079
Shutting Down	-1.2283	-0.8752	-0.7549
Changes Percent	↑ 29.58%	↓ 23.91%	↓ 24.18%

Notes: (1) The definition of cumulative multiplier is explained in Appendix 3.I; (2) These numbers are calculated from the estimated and simulated impulse response functions employing Matlab; (3) The ↑ indicates increase for cumulative output multipliers, while ↓ implies decreases for cumulative unemployment rate multipliers, as they are negative, decreasing suggests that the impact become stronger; (4) The counterfactuals of shutting down the public physical capital externality channel are calculated with $\alpha^g = 0.00$.

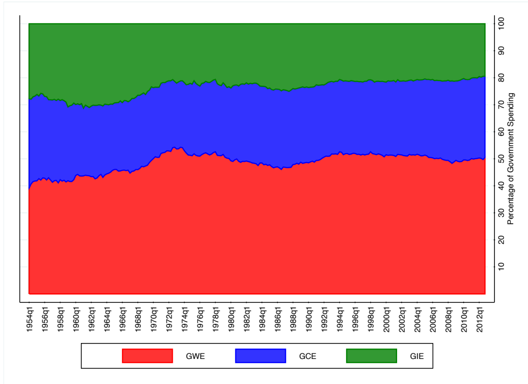
3.C Main Figures

Figure 3.1: The Government Spending and Its Components: 1954Q1 to 2012Q4

(a) The Level



(b) The Share

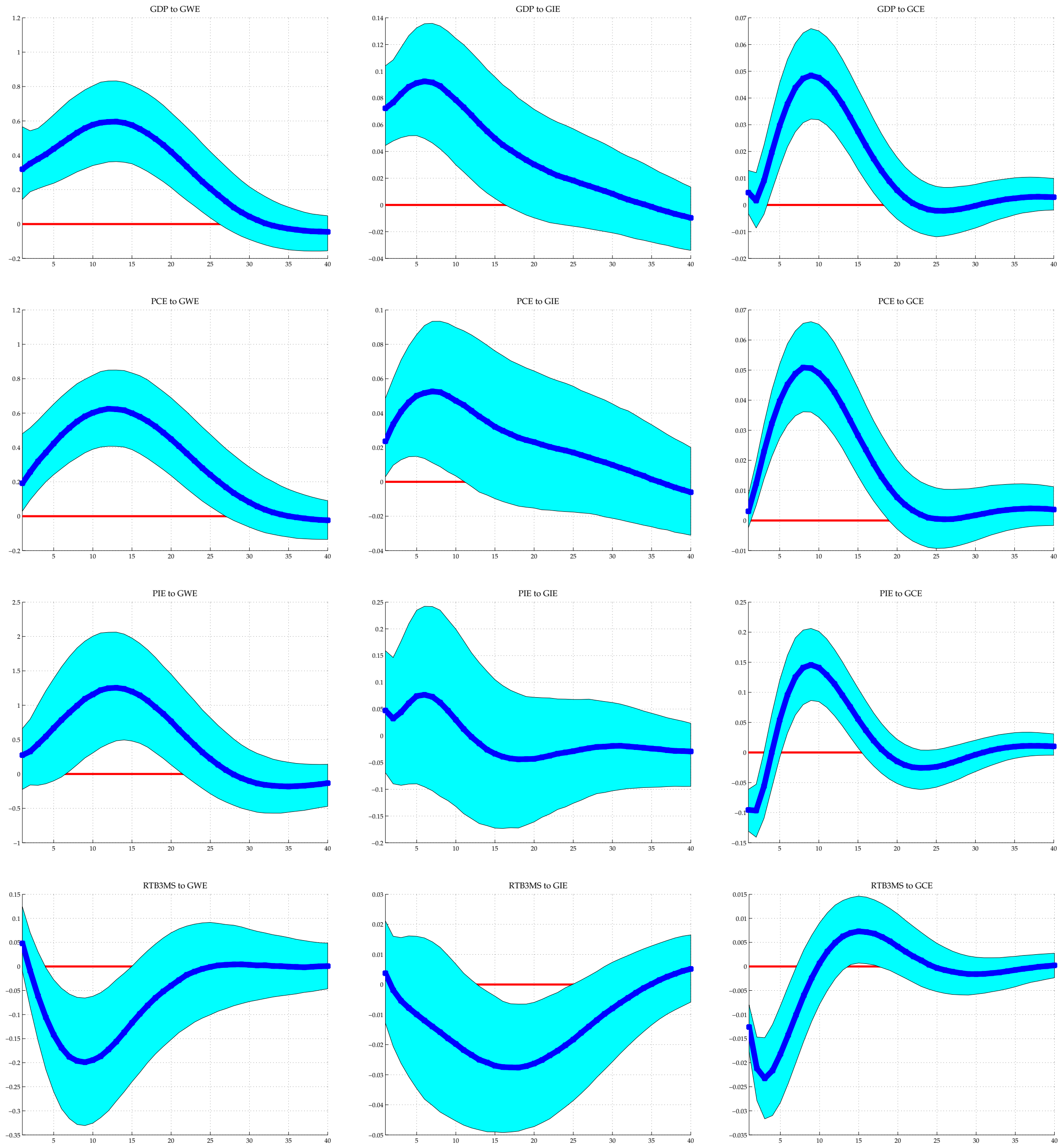


Notes: (1) GST indicates total government spending, GWE represents government wage expenditure, GCE indicates government consumption expenditure, GIE is an abbreviation of government investment expenditure; (2) The grey bar in Figure 1a indicates the NBER-defined recessions; (3) The data for Figure 1a comes from NIPA Tables from the Bureau of Economic Analysis, Department of Commerce, the United States of America; (4) The data for Figure 1b is from author's own calculation based on the raw data from NIPA Tables.

Figure 3.2: The U.S. Output and Labor Market Facts: 1954Q1 to 2012Q4

Figure 3.3.1: The Dynamic Effects of Different Expenditure Shocks on U.S. Economy

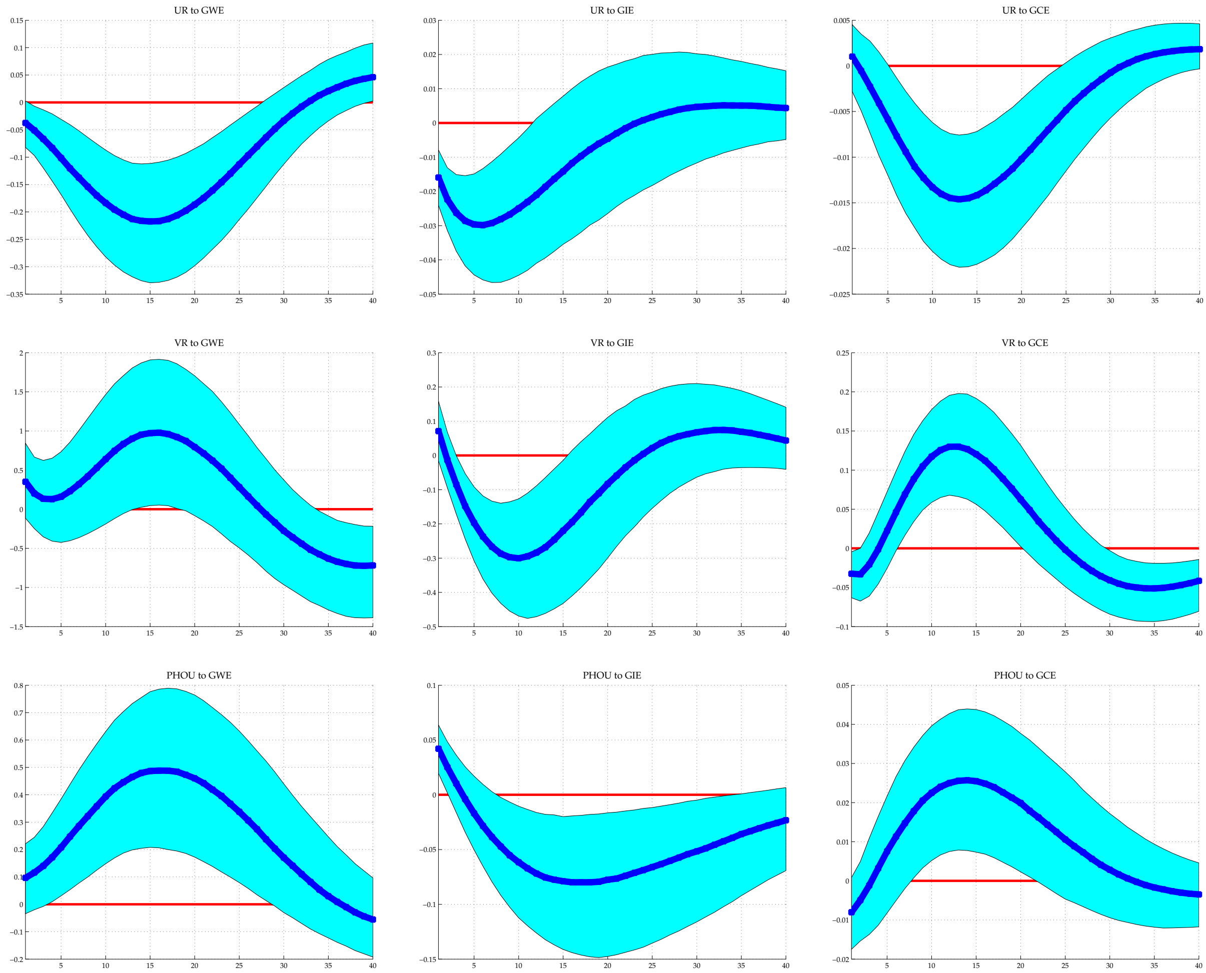
Response to GWE Response to GIE Response to GCE



Notes: (1) The ± 1 *standard error bands are plotted as in Stock and Watson (2001), yielding an approximate 66% confidence interval; (2) The number of draws for bootstrapping is set at 5000 to obtain more smooth and reliable estimates.*

Figure 3.3.2: The Dynamic Effects of Expenditure Shocks on Labor Market I

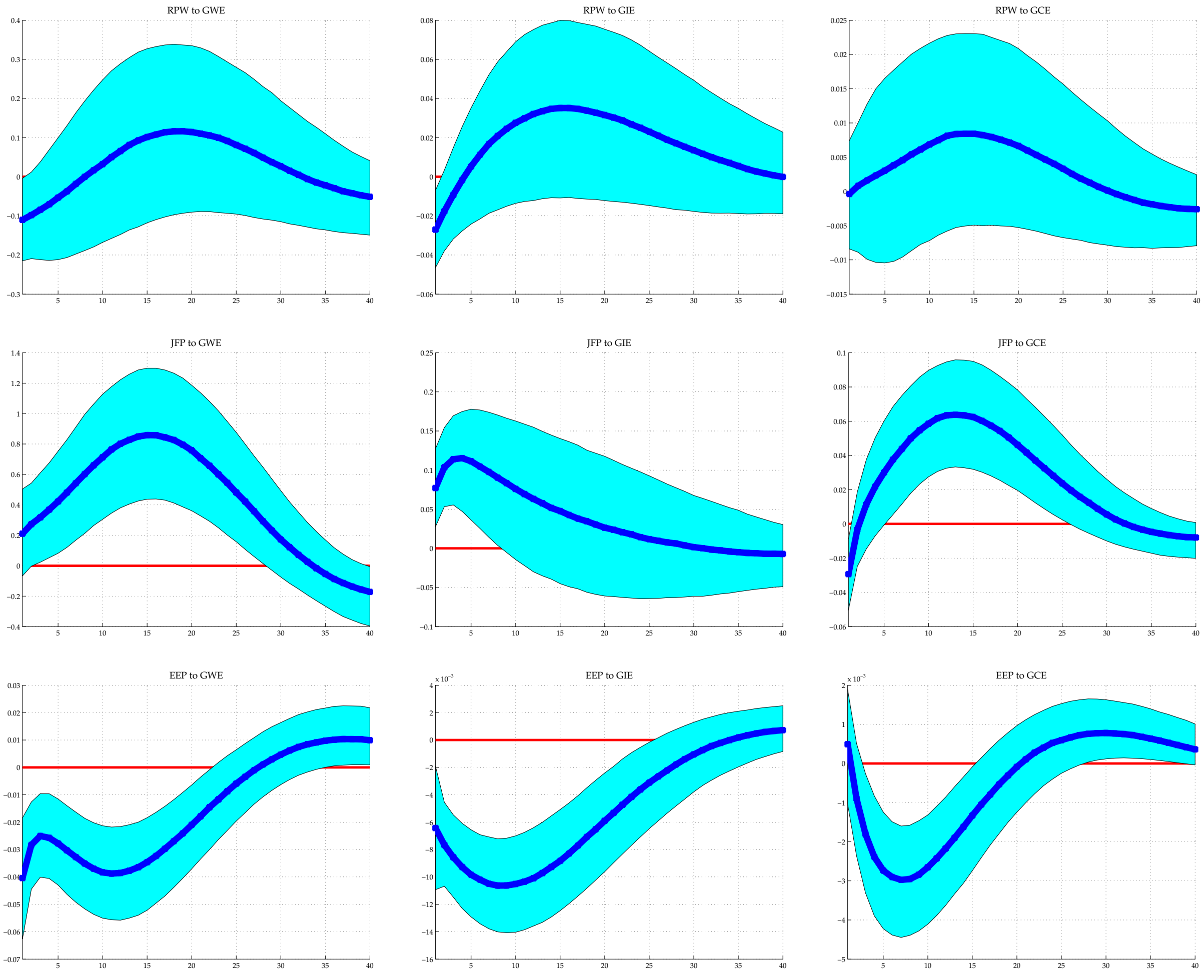
Response to GWE | Response to GIE | Response to GCE



Notes: (1) The ± 1 *standard error bands are plotted as in Stock and Watson (2001), yielding an approximate* 66% *confidence interval; (2) The number of draws for bootstrapping is set at 5000 to obtain more smooth and reliable estimates.*

Figure 3.3.3: The Dynamic Effects of Expenditure Shocks on Labor Market II

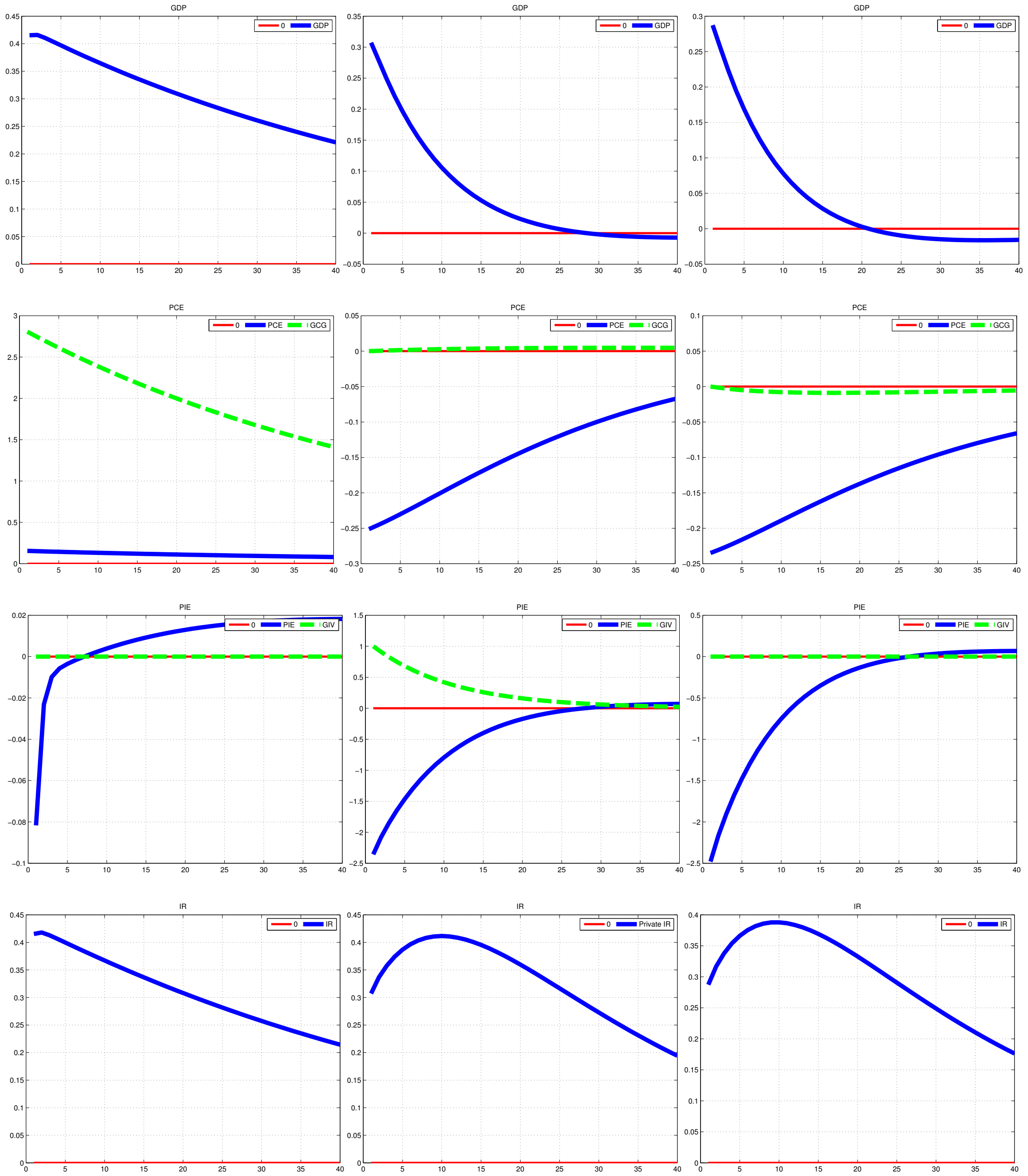
Response to GWE Response to GIE Response to GCE



Notes: (1) The ± 1 *standard error bands are plotted as in Stock and Watson (2001), yielding an approximate* 66% *confidence interval; (2) The number of draws for bootstrapping is set at 5000 to obtain more smooth and reliable estimates.*

Figure 3.4.1: The Simulated Effects of Different Expenditure Shocks on U.S. Economy

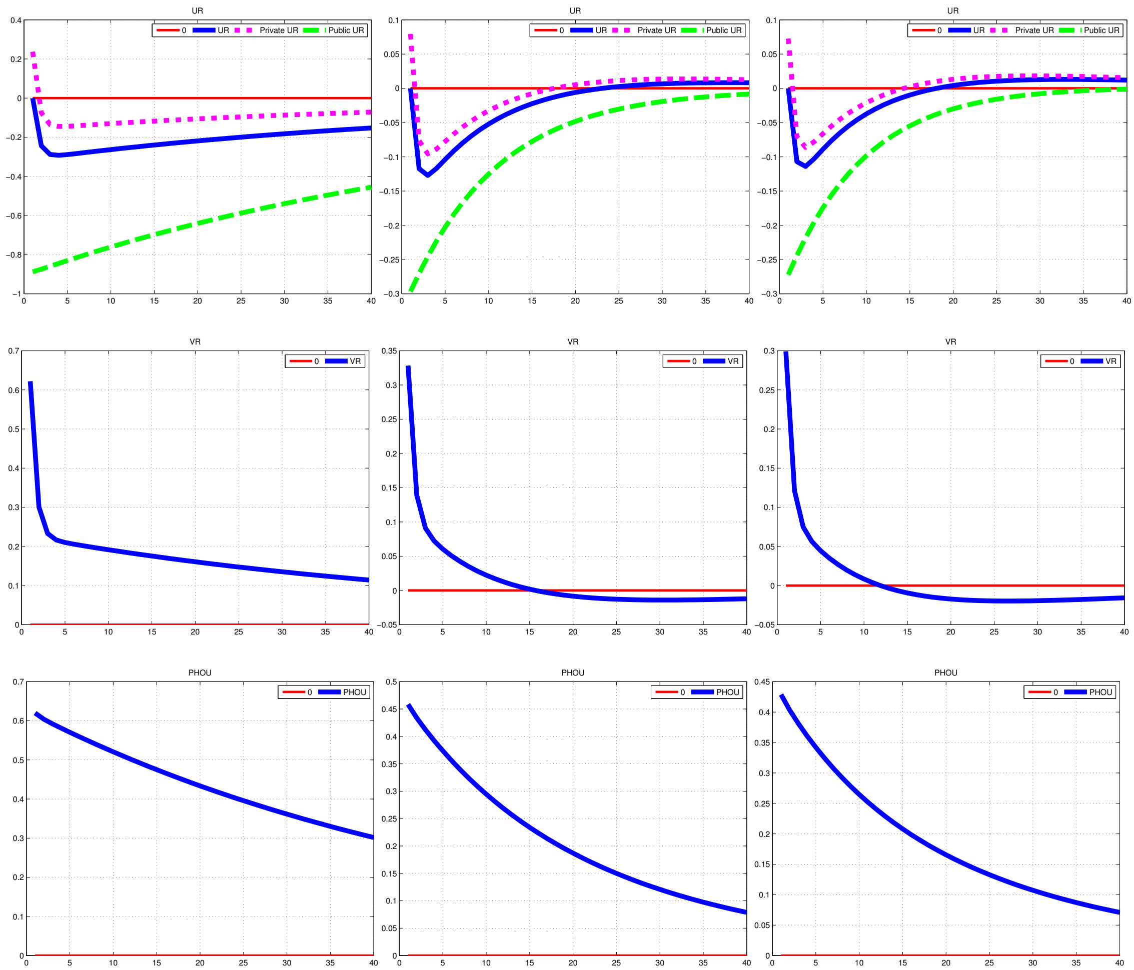
Response to GWE Response to GIE Response to GCE



Notes: (1) The impulse response functions plotted here are from the benchmark simulation results; (2) Green color indicates the corresponding government sector variables; (3) Magenta color represents a private sector variable; (4) Blue color represents the aggregate variable.

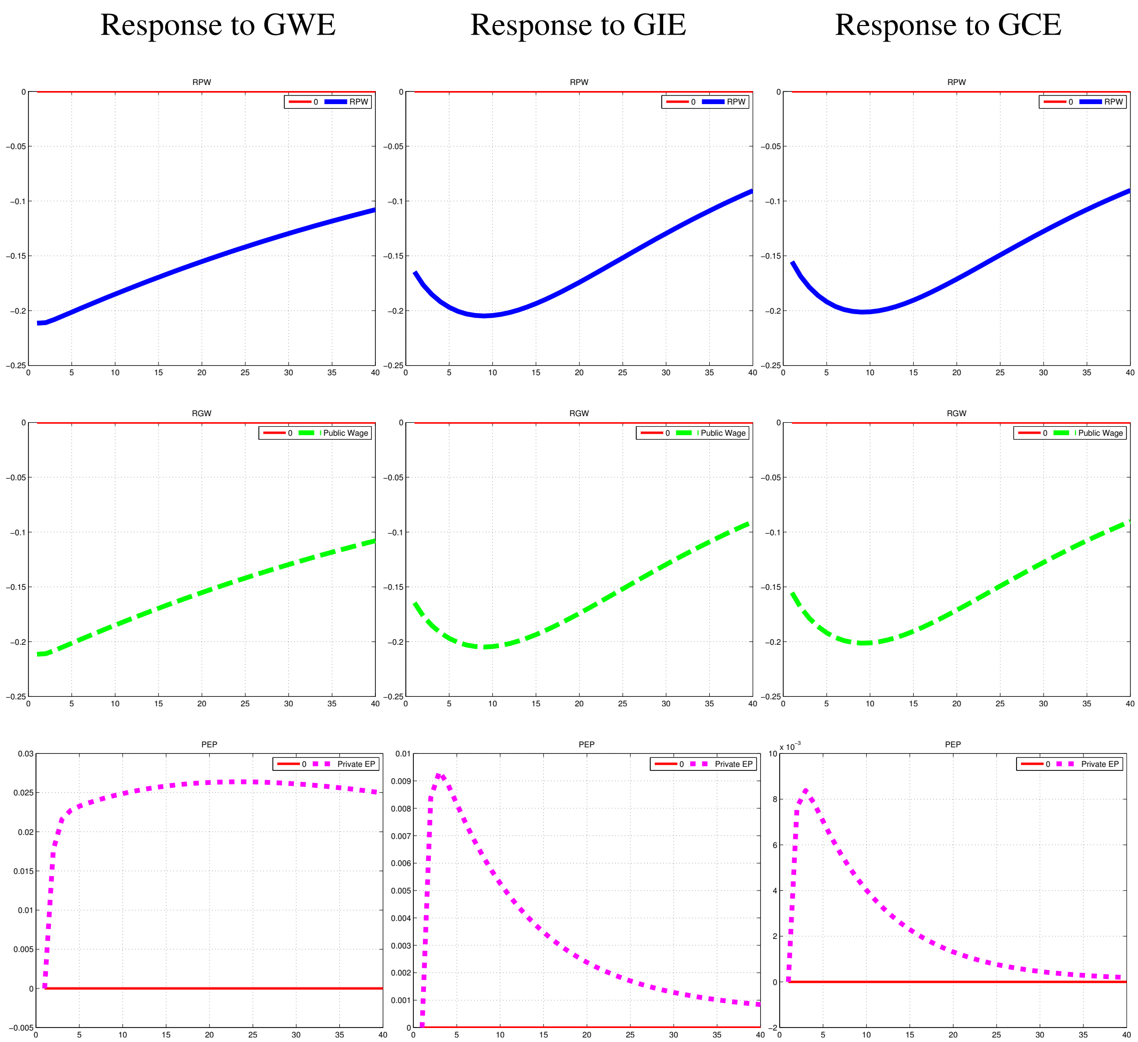
Figure 3.4.2: The Simulated Effects of Different Shocks on Labor Market I

Response to GWE | Response to GIE | Response to GCE



Notes: (1) The impulse response functions plotted here are from the benchmark simulation results; (2) Green color indicates the corresponding government sector variables; (3) Magenta color represents a private sector variable; (4) Blue color represents the aggregate variable.

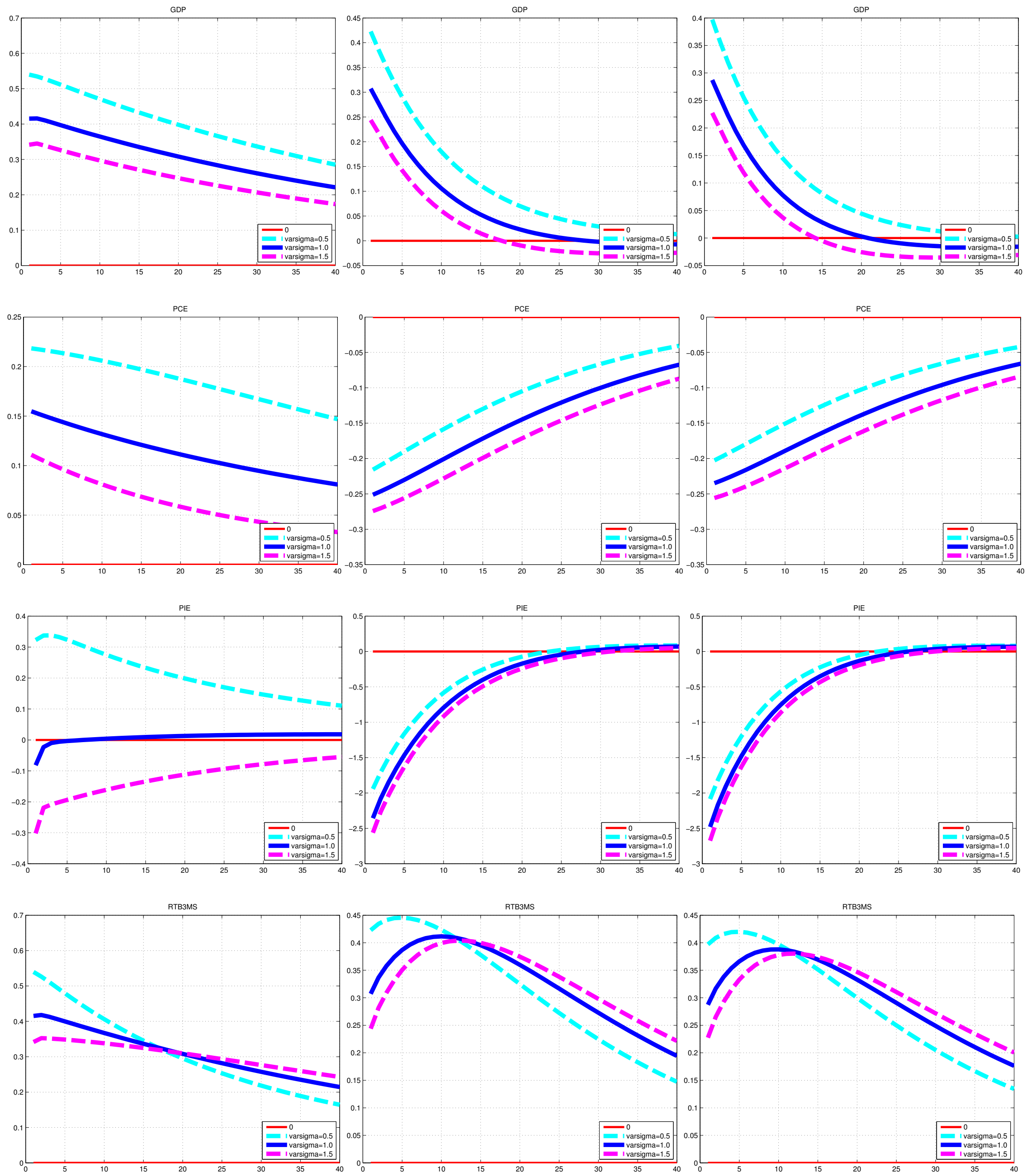
Figure 3.4.3: The Simulated Effects of Different Shocks on Labor Market II



Notes: (1) The impulse response functions plotted here are from the benchmark simulation results; (2) Green color indicates the corresponding government sector variables; (3) Magenta color represents a private sector variable; (4) Blue color represents the aggregate variable.

Figure 3.5.1: The Simulated Responses for Alternative ς I

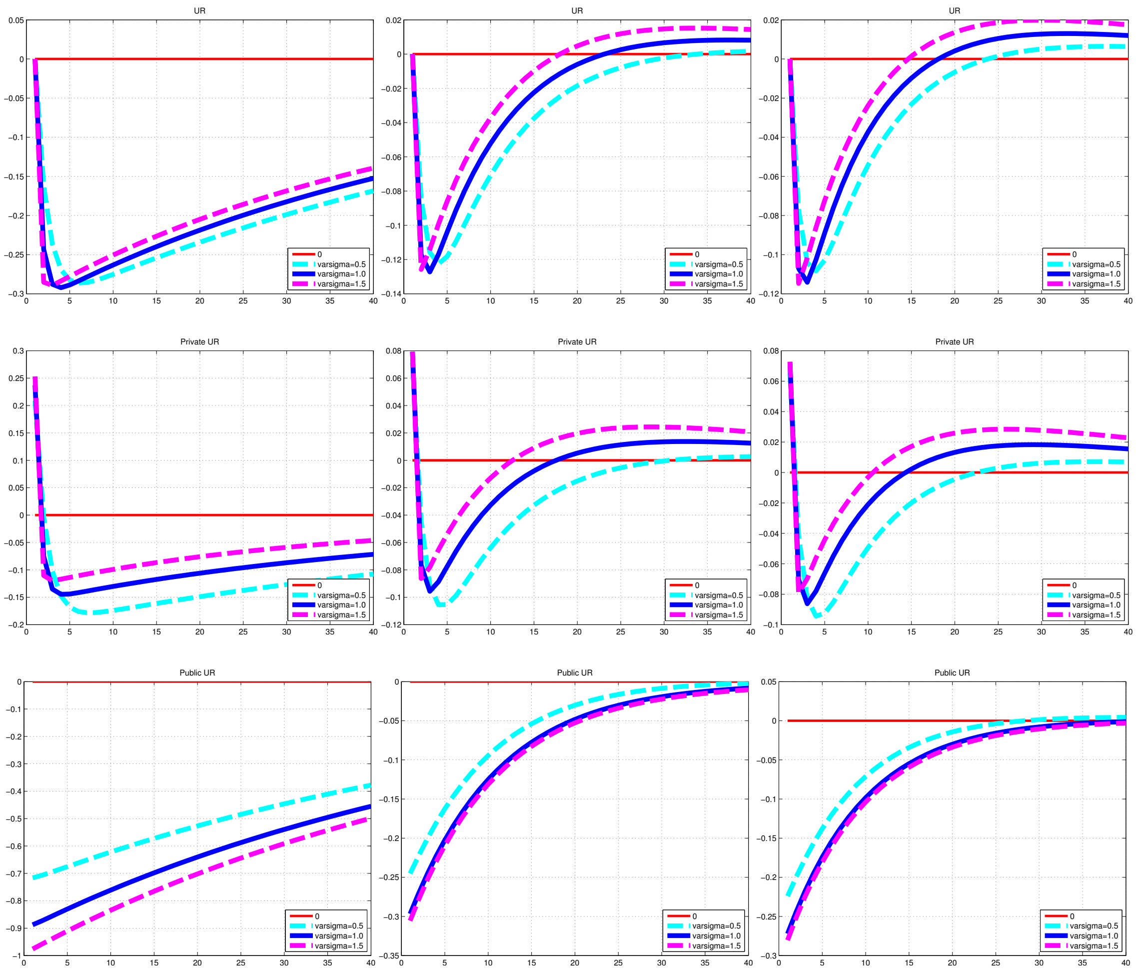
Response to GWE | Response to GIE | Response to GCE



Notes: (1) The impulse response functions plotted here are from the simulation for sensitivity analysis; (2) Blue color indicates the impulse responses from the benchmark simulation; (3) Cyan color indicates the impulse responses from the simulation with smaller values of ς; (4) Magenta color indicates the impulse responses from the simulation with bigger values of ς.

Figure 3.5.2: The Simulated Responses for Alternative ς II

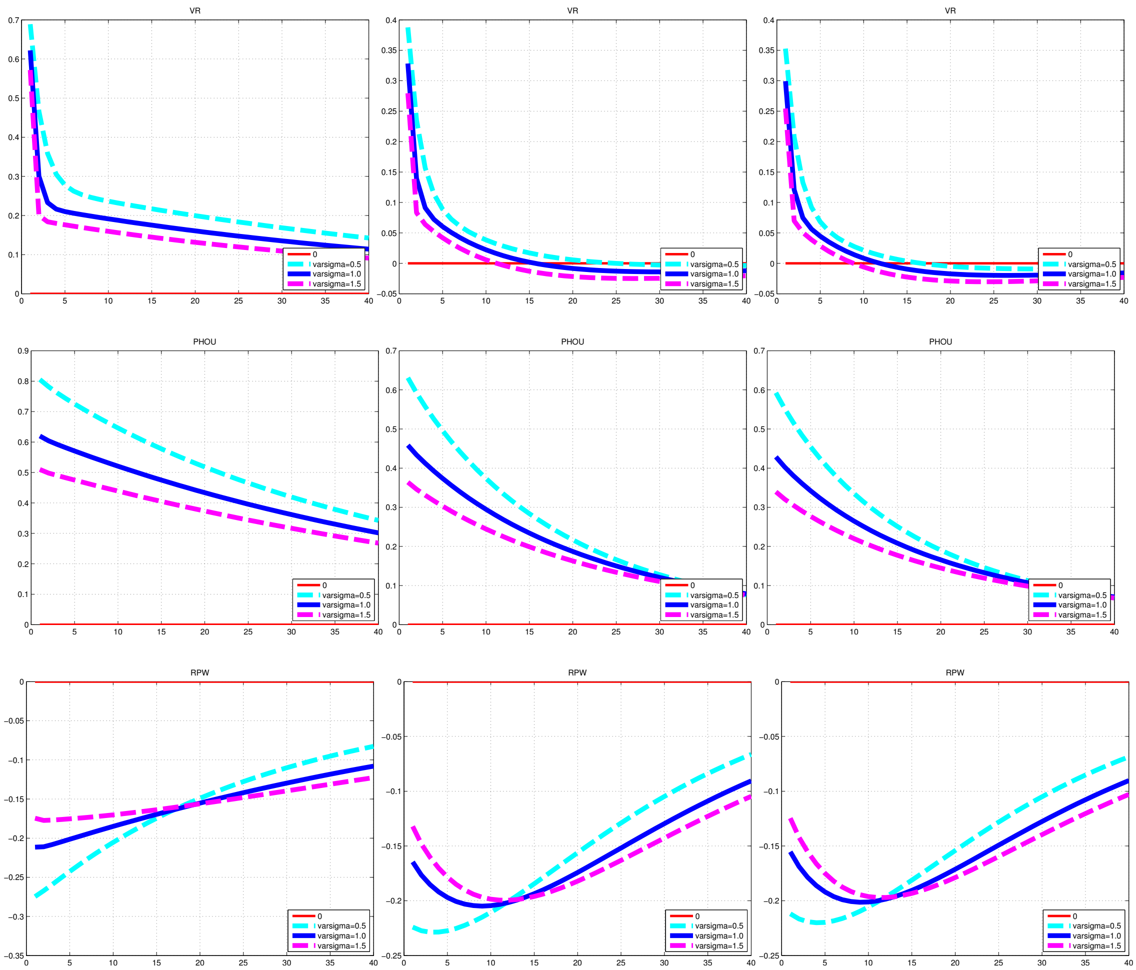
Response to GWE Response to GIE Response to GCE



Notes: (1) The impulse response functions plotted here are from the simulation for sensitivity analysis; (2) Blue color indicates the impulse responses from the benchmark simulation; (3) Cyan color indicates the impulse responses from the simulation with smaller values of ς; (4) Magenta color indicates the impulse responses from the simulation with bigger values of ς.

Figure 3.5.3: The Simulated Responses for Alternative ς III

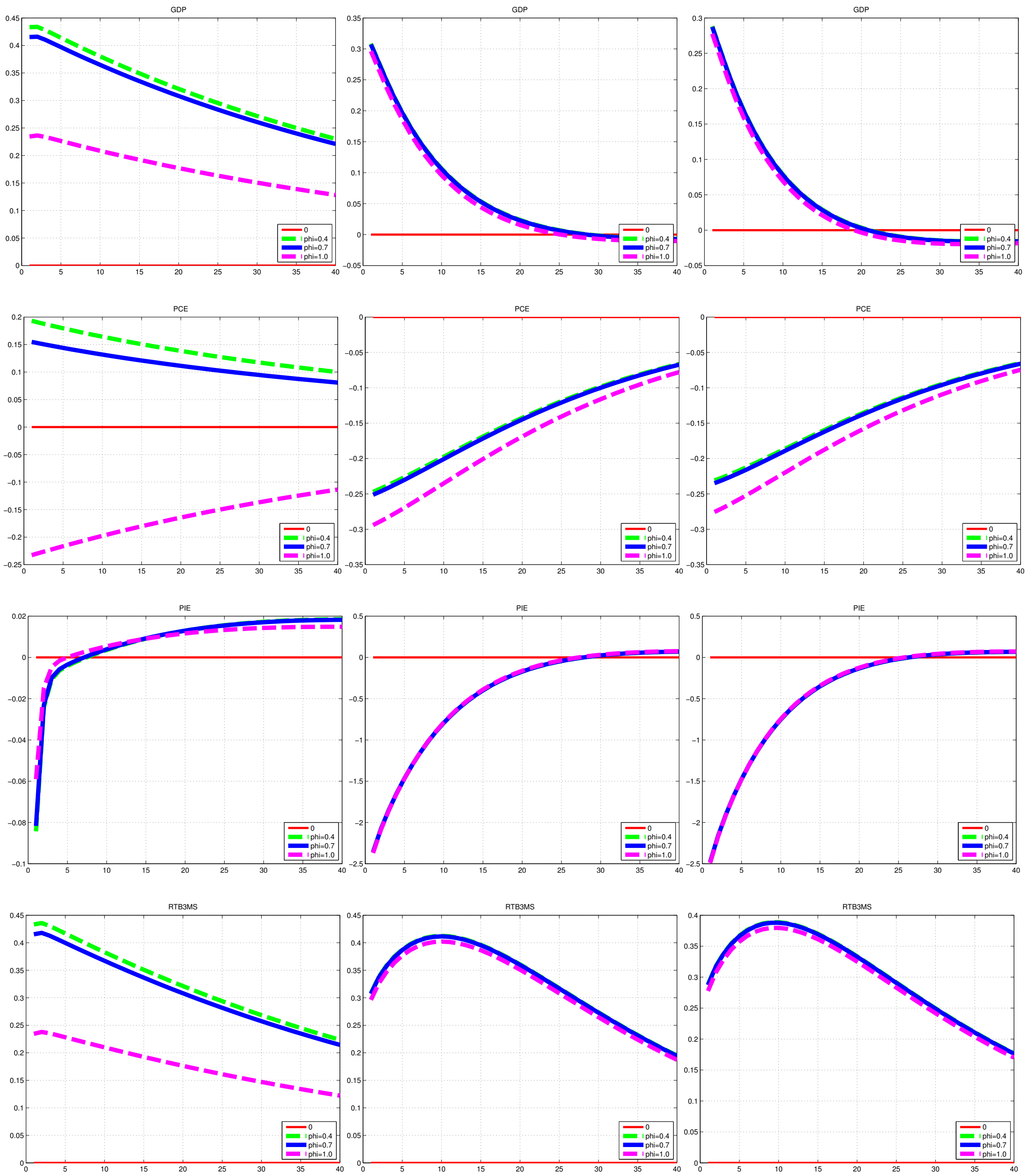
Response to GWE Response to GIE Response to GCE



Notes: (1) The impulse response functions plotted here are from the simulation for sensitivity analysis; (2) Blue color indicates the impulse responses from the benchmark simulation; (3) Cyan color indicates the impulse responses from the simulation with smaller values of ς; (4) Magenta color indicates the impulse responses from the simulation with bigger values of ς.

Figure 3.A.1: The Simulated Responses for Alternative ϕ I

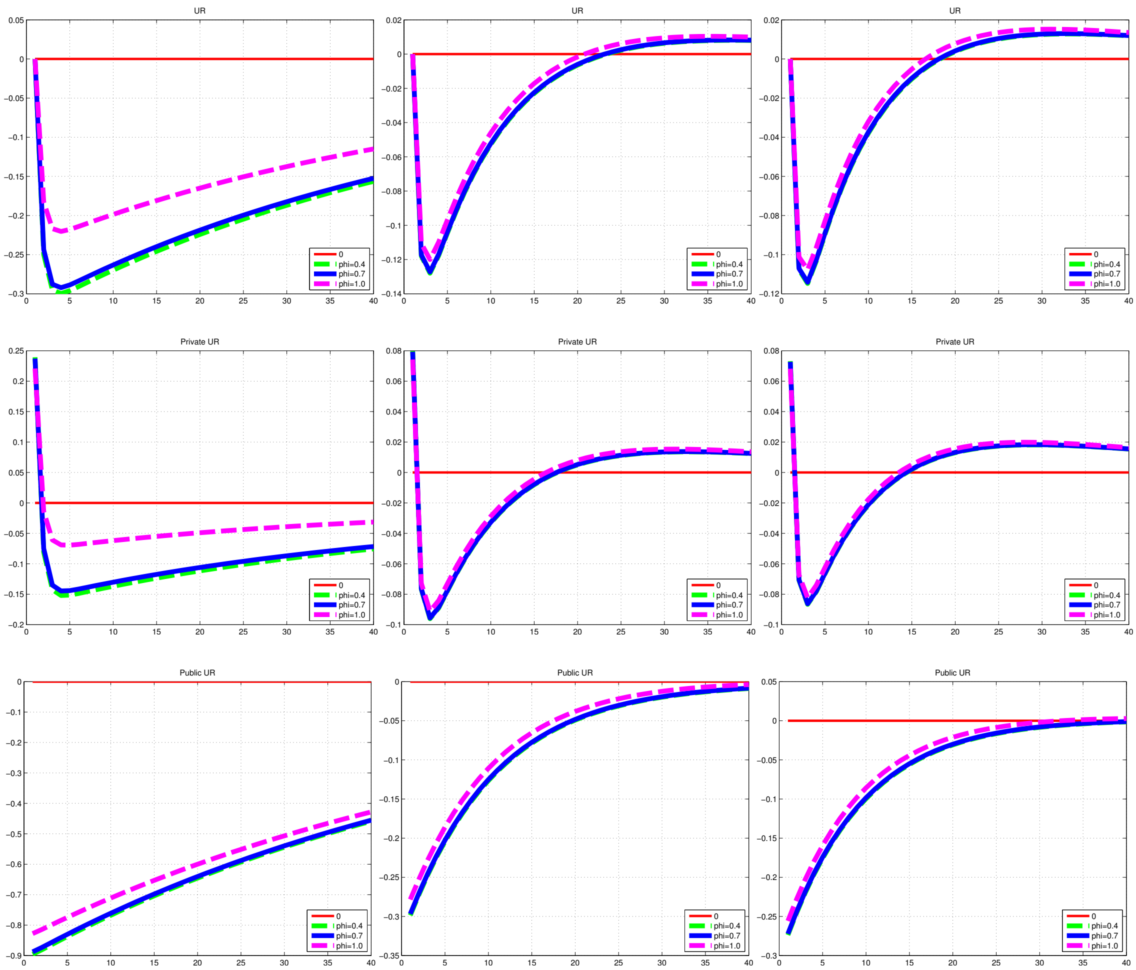
Response to GWE Response to GIE Response to GCE



Notes: (1) The impulse response functions plotted here are from the simulation for evaluating the complementarity between private goods and public products in private consumption; (2) Blue color indicates the impulse responses from the benchmark simulation; (3) Green color indicates the impulse responses from the simulation with smaller values of ϕ; (4) Magenta color indicates the impulse responses from the simulation with bigger values of ϕ.

Figure 3.A.2: The Simulated Responses for Alternative ϕ II

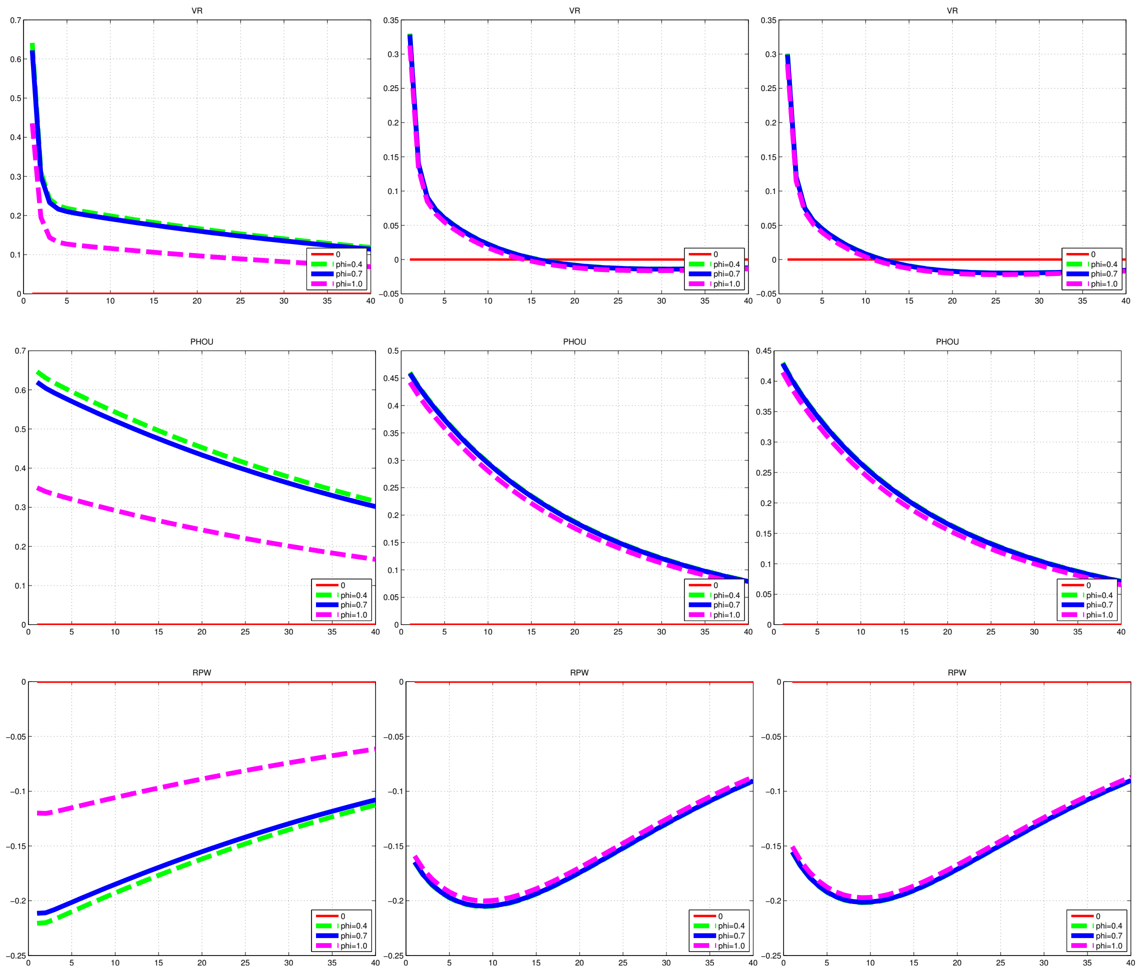
Response to GWE　　Response to GIE　　Response to GCE



Notes: (1) The impulse response functions plotted here are from the simulation for evaluating the complementarity between private goods and public products in private consumption; (2) Blue color indicates the impulse responses from the benchmark simulation; (3) Green color indicates the impulse responses from the simulation with smaller values of ϕ*; (4) Magenta color indicates the impulse responses from the simulation with bigger values of* ϕ*.*

Figure 3.A.3: The Simulated Responses for Alternative ϕ III

Response to GWE Response to GIE Response to GCE



Notes: (1) The impulse response functions plotted here are from the simulation for evaluating the complementarity between private goods and public products in private consumption; (2) Blue color indicates the impulse responses from the benchmark simulation; (3) Green color indicates the impulse responses from the simulation with smaller values of ϕ*; (4) Magenta color indicates the impulse responses from the simulation with bigger values of* ϕ.

3.D Data Source and Description

I: National Income and Product Account (NIPA), Bureau of Economic Analysis (BEA)

I-1: NIPA Table 1.1.5. Gross Domestic Product, Billions of dollars, Seasonally adjusted at annual rates

1. (L1) Gross domestic product;

2. (L2) Personal consumption expenditures;

3. (L7) Gross private domestic investment;

4. (L22) Government consumption expenditures and gross investment;

I-2: NIPA Table 1.1.9. Implicit Price Deflators for Gross Domestic Product, Index numbers, 2009=100, Seasonally adjusted

5. (L1) Gross domestic product;

6. (L2) Personal consumption expenditures;

7. (L7) Gross private domestic investment;

8. (L22) Government consumption expenditures and gross investment;

I-3: NIPA Table 3.1. Government Current Receipts and Expenditures, Billions of dollars, Seasonally adjusted at annual rates

9. (L29) Total receipts;

10. (L32) Total expenditures;

11. (L33) Current expenditures;

12. (L34) Gross government investment;

I-4: NIPA Table 3.9.4. Price Indexes for Government Consumption Expenditures and Gross Investment, Index numbers, 2009=100, Seasonally adjusted

13. (L1) Government consumption expenditures and gross investment;

14. (L2) Consumption expenditures;

15. (L3) Gross investment;

I-5: NIPA Table 3.9.5. Government Consumption Expenditures and Gross Investment, Billions of dollars, Seasonally adjusted at annual rates

16. (L1) Government consumption expenditures and gross investment;

17. (L2) Consumption expenditures;

18. (L3) Gross investment;

I-6: NIPA Table 3.9.6. Real Government Consumption Expenditures and Gross Investment, Chained Dollars, Billions of chained (2009) dollars, Seasonally adjusted at annual rates

19. (L1) Government consumption expenditures and gross investment;

20. (L2) Consumption expenditures;

21. (L3) Gross investment;

I-7: NIPA Table 3.10.4. Price Indexes for Government Consumption Expenditures and General Government Gross Output, Index numbers, 2009=100, Seasonally adjusted

22. (L1) Government consumption expenditures;

23. (L2) Gross output of general government;

24. (L3) Value added;

25. (L4) Compensation of general government employees;

26. (L5) Consumption of general government fixed capital;

27. (L6) Intermediate goods and services purchased;

28. (L7) Durable goods;

29. (L8) Nondurable goods;

30. (L9) Services;

31. (L10) Less: Own-account investment;

32. (L11) Less: Sales to other sectors;

I-8: NIPA Table 3.10.5. Government Consumption Expenditures and General Government Gross Output, Billions of dollars, Seasonally adjusted at annual rates[22]

[22]Note: The relationship among those lines: (a) $L1 = L2 - L10 - L11$; (b)$L2 = L3 + L6$; (c) $L3 = L4 + L5$; (d) $L6 = L7 + L8 + L9$.

33. (L1) Government consumption expenditures;

34. (L2) Gross output of general government;

35. (L3) Value added;

36. (L4) Compensation of general government employees;

37. (L5) Consumption of general government fixed capital;

38. (L6) Intermediate goods and services purchased;

39. (L7) Durable goods;

40. (L8) Nondurable goods;

41. (L9) Services;

42. (L10) Less: Own-account investment;

43. (L11) Less: Sales to other sectors;

I-9: NIPA Table 3.10.6. Real Government Consumption Expenditures and General Government Gross Output, Chained Dollars[23]

44. (L1) Government consumption expenditures;

45. (L2) Gross output of general government;

46. (L3) Value added;

47. (L4) Compensation of general government employees;

48. (L5) Consumption of general government fixed capital;

49. (L6) Intermediate goods and services purchased;

50. (L7) Durable goods;

51. (L8) Nondurable goods;

52. (L9) Services;

53. (L10) Less: Own-account investment;

54. (L11) Less: Sales to other sectors;

II: Bureau of Labor Statistics (BLS)

55. Total Nonfarm Employment, CES0000000001;

56. Total Private Employment, CES0500000001;

[23]These real series are available at quarterly frequency from 1999Q1.

57. Government Employment, CES9000000001;

III: Federal Reserve Economic Data, Federal Reserve Bank of St. Louis

58. Business Sector: Hours of All Persons (HOABS);
59. Nonfarm Business Sector: Hours of All Persons (HOANBS);
60. Business Sector: Compensation Per Hour (HCOMPBS);
61. Business Sector: Real Compensation Per Hour (RCPHBS);
62. Business Sector: Real Output Per Hour of All Persons (OPHPBS);
63. Effective Federal Funds Rate (FEDFUNDS);
64. Consumer Price Index for All Urban Consumers: All Items (CPIAUCSL);
65. 3-Month Treasury Bill: Secondary Market Rate (TB3MS);
66. Civilian Labor Force (CLF16OV);
67. Unemployed (UNEMPLOY);
68. Civilian Unemployment Rate (UNRATE);
69. All Employees: Total Private Industries (USPRIV);
70. Job Openings Total Nonfarm (JTSJOL);
71. Job Openings: Total Private (JTS1000JOL);
72. Civilian Noninstitutional Population (CNP16OV);
73. Total Population: All Ages including Armed Forces Overseas (POP);

IV: The Conference Board Help Wanted Online (HWOL);

74. HWOL National Data: May, 2005 to December, 2013;
75. HWOL Index: January 1951 to March 2005;

V: OECD.Stat, Organization for Economic Co-Operation and Development

76. Unit Labor Cost;

VI: Valerie A. Ramey and Neville Ricardo Francis (2013)

77. Total Hours and Employment;

VII: Robert Shimer (2012)

78. Job Finding Rate;
79. Employment Exit Rate;

VIII: Valerie A. Ramey and Matthew D. Shapiro (1998)

80. Ramey and Shapiro War Dates;

IX: National Bureau of Economic Research

81. US Business Cycle Expansions and Contractions.

X: Bureau of Labor Statistics

82. Current Population Survey Monthly Data from 1976M1 to 2012M12

3.E The Specification of Reduced Form VAR

As in Bruckner and Pappa (2012), Kuo and Miyamoto (2013), and Monacelli et al. (2010), our benchmark specification for the reduced-form VAR model is:

$$Y_t = b_0 + b_1 t^2 + C(L) Y_{t-1} + D(L) RSWD_t + \varepsilon_t \tag{3.E1}$$

where $Y_t = (GE_t, GDP_t, PCE_t, PIE_t, RTB3MS_t, X_t)$, GE_t indicates the government spending component which is replaced by government wage expenditure GWE_t, government consumption expenditure GCE_t, and government investment GI_t, respectively, in the estimation of the VAR model. $C(L)$ and $D(L)$ are the matrix polynomial of the lag operator. b_0 is the constant. b_1 captures the quadratic trend. X_t represents the labor market variables to be examined in each specification, which is replaced by unemployment rate UR_t, vacancy index VR_t, private hours worked $PHOU_t$, job finding probability JFP_t, employment exit probability EEP_t, and real private wage index RPW_t. ε_t is the corresponding reduced form disturbance terms (forecasting shocks) with mean 0 and variance-covariance matrix $Var(\varepsilon_t) = \sum_{\varepsilon}$.

Let u_t indicate the corresponding structural form disturbance terms (orthogonal shocks) with mean 0 and variance-covariance matrix $Var(u_t) = I$, where I is the identity matrix. The identification strategy of Blanchard and Perotti (2002), Perotti (2005), Galí et al. (2007), and Ilzetzki et al. (2013) imply that the forecasting shocks are related to the orthogonal shocks as follows

$$
\begin{pmatrix} \varepsilon_{GEt} \\ \varepsilon_{GDPt} \\ \varepsilon_{PCEt} \\ \varepsilon_{PIEt} \\ \varepsilon_{RTBt} \\ \varepsilon_{Xt} \end{pmatrix} = \begin{bmatrix} \Psi(1,1) & 0 & 0 & 0 & 0 & 0 \\ \Psi(2,1) & \Psi(2,2) & 0 & 0 & 0 & 0 \\ \Psi(3,1) & \Psi(3,2) & \Psi(3,3) & 0 & 0 & 0 \\ \Psi(4,1) & \Psi(4,2) & \Psi(4,3) & \Psi(4,4) & 0 & 0 \\ \Psi(5,1) & \Psi(5,2) & \Psi(5,3) & \Psi(5,4) & \Psi(5,5) & 0 \\ \Psi(6,1) & \Psi(6,2) & \Psi(6,3) & \Psi(6,4) & \Psi(6,5) & \Psi(6,6) \end{bmatrix} \begin{pmatrix} u_{GEt} \\ u_{GDPt} \\ u_{PCEt} \\ u_{PIEt} \\ u_{RTBt} \\ u_{Xt} \end{pmatrix} \tag{3.E2}
$$

where $\sum_{\varepsilon} = \Psi\Psi'$.

3.F Proof of Key Equations

Proof of Equation (3.11) **and Equation** (3.12)

Setting up he Lagrangian of the household's problem

$$
\begin{aligned}
\mathscr{L}_d &= \sum_{t=0}^{\infty}\beta^t \left\{ \frac{\left\{\left[\phi\left(c_t^p\right)^{\frac{\zeta-1}{\zeta}}+(1-\phi)\left(c_t^g\right)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{\zeta}{\zeta-1}}\right\}^{1-\sigma}-1}{1-\sigma} \right. \\
&\quad -\psi n_t^p\frac{\left(h_t^p\right)^{1+\varsigma}}{1+\varsigma}-\psi n_t^g\frac{\left(h_t^g\right)^{1+\varsigma}}{1+\varsigma}+\varphi_t\left[w_t^p h_t^p n_t^p+w_t^g h_t^g n_t^g+u_t z_t+r_t^p K_t^p\right. \\
&\quad \left.\left.+\left(1-\delta^p\right)K_t^p+\Pi_t-T_t-c_t^p-K_{t+1}^p\right]\right\} \qquad (3.F1)
\end{aligned}
$$

The first order conditions are given by:

c_t^p: $\left[\left(\dot{c}_t\right)^{\frac{\zeta}{\zeta-1}}\right]^{-\sigma}\left(\dot{c}_t\right)^{\frac{1}{\zeta-1}}\phi\left(c_t^p\right)^{\frac{-1}{\zeta}}=\varphi_t$

K_{t+1}^p: $\varphi_t=\beta\mathbb{E}_t\varphi_{t+1}\left(1+r_{t+1}^p-\delta^p\right)$

where $\dot{c}_t=\phi\left(c_t^p\right)^{\frac{\zeta-1}{\zeta}}+(1-\phi)\left(c_t^g\right)^{\frac{\zeta-1}{\zeta}}$.

Proof of Equation (3.16)

Plugging (3.14) into (3.15),

$$
\begin{aligned}
\text{LHS} &= \beta\mathbb{E}_t\frac{\varphi_{t+1}}{\varphi_t}\left[p_t^p W_{t+1}^p+\left(1-p_t^p\right)U_{t+1}\right] \\
&= \beta\mathbb{E}_t\frac{\varphi_{t+1}}{\varphi_t}\left(\frac{u_t^p p_t^p}{u_t^p}W_{t+1}^p-\frac{u_t^p p_t^p}{u_t^p}U_{t+1}+U_{t+1}\right) \\
&= \beta\mathbb{E}_t\frac{\varphi_{t+1}}{\varphi_t}\left[\frac{m_t^p\left(W_{t+1}^p-U_{t+1}\right)}{u_t^p}+U_{t+1}\right] \qquad (3.F2)
\end{aligned}
$$

$$
\begin{aligned}
\text{RHS} &= \beta \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} \left[p_t^g W_{t+1}^g + \left(1 - p_t^g\right) U_{t+1}^g \right] \\
&= \beta \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} \left(\frac{u_t^g p_t^g}{u_t^g} W_{t+1}^g - \frac{u_t^g p_t^g}{u_t^g} U_{t+1} + U_{t+1} \right) \\
&= \beta \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} \left[\frac{m_t^g \left(W_{t+1}^g - U_{t+1}\right)}{u_t^g} + U_{t+1} \right] \qquad (3.F3)
\end{aligned}
$$

Canceling common terms in (3.F2) and (3.F3),

$$
\begin{aligned}
\text{LHS} &= \mathbb{E}_t \frac{m_t^p \frac{\varphi_{t+1}}{\varphi_t} \left(W_{t+1}^p - U_{t+1}\right)}{u_t^p} \qquad (3.F4) \\
\text{RHS} &= \mathbb{E}_t \frac{m_t^g \frac{\varphi_{t+1}}{\varphi_t} \left(W_{t+1}^g - U_{t+1}\right)}{u_t^g} \qquad (3.F5)
\end{aligned}
$$

Multiplying both sides of (3.F4) and (3.F5) by u_t,

$$
\begin{aligned}
\text{LHS} &= \mathbb{E}_t \frac{m_t^p \frac{\varphi_{t+1}}{\varphi_t} \left(W_{t+1}^p - U_{t+1}\right)}{1 - s_t} \qquad (3.F6) \\
\text{RHS} &= \mathbb{E}_t \frac{m_t^g \frac{\varphi_{t+1}}{\varphi_t} \left(W_{t+1}^g - U_{t+1}\right)}{s_t} \qquad (3.F7)
\end{aligned}
$$

Equating (3.F6) and (3.F7) delivers (3.16).

Proof of Equation (3.23)

Plugging (3.22) into (3.21) delivers

$$
\frac{\iota^p}{q_t^p} = \beta \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} \left(J_{t+1}\right) \qquad (3.F8)
$$

From (3.18), (3.22), and (3.19), we get

$$J_{t+1}=y^p_{t+1}-w^p_{t+1}h^p_{t+1}-r^p_{t+1}k^p_{t+1}+\beta\mathbb{E}_{t+1}\frac{\varphi_{t+2}}{\varphi_{t+1}}\left[\left(1-\lambda^p\right)J_{t+2}\right] \tag{3.F9}$$

update (3.F8) one period ahead,

$$\frac{\iota^p}{q^p_{t+1}}=\beta\mathbb{E}_t\frac{\varphi_{t+2}}{\varphi_{t+1}}\left(J_{t+2}\right) \tag{3.F10}$$

Plugging (3.F9) and (3.F10) into (3.F8) delivers

$$\frac{\iota^p}{q^p_t}=\beta\mathbb{E}_t\frac{\varphi_{t+1}}{\varphi_t}\left[y^p_{t+1}-w^p_{t+1}h^p_{t+1}-r^p_{t+1}k^p_{t+1}+\left(1-\lambda^p\right)\frac{\iota^p}{q^p_{t+1}}\right] \tag{3.F11}$$

equation (3.F11) is the job creation condition.

Proof of Equations (3.25) **and** (3.26)

From the Nash product (3.24), (3.13), (3.14), (3.15), (3.18), and (3.22), the FOC w.r.t private wage is

$$\begin{aligned} \text{LHS} &= \xi\left(W^p_t-U^p_t\right)^{\xi-1}\left(J_t-V_t\right)^{1-\xi}\frac{\partial W^p_t}{\partial w^p_t} && (3.F12)\\ \text{RHS} &= -\left(1-\xi\right)\left(W^p_t-U^p_t\right)^{\xi}\left(J_t-V_t\right)^{-\xi}\frac{\partial J_t}{\partial w^p_t} && (3.F13)\end{aligned}$$

As $\frac{\partial W^p_t}{\partial w^p_t}=h^p_t$, $\frac{\partial J_t}{\partial w^p_t}=-h^p_t$, and

$$W^p_t-U_t=w^p_th^p_t-\psi\frac{\left(h^p_t\right)^{1+\varsigma}}{\varphi_t\left(1+\varsigma\right)}-z_t+\beta\left(1-\lambda^p-p^p_t\right)\mathbb{E}_t\frac{\varphi_{t+1}}{\varphi_t}\left(W^p_{t+1}-U_{t+1}\right) \tag{3.F14}$$

Combing (3.F12) with (3.F13), and canceling common terms,

$$\xi J_t = \left(1-\xi\right)\left(W^p_t-U_t\right) \tag{3.F15}$$

thus $W_t^p - U_t = \frac{\xi}{1-\xi} J_t$, as $S_t = W_t^p - U_t + J_t$, then $J_t = (1-\xi) S_t$ and $W_t^p - U_t = \xi S_t$.

Update (3.F24) one period ahead: $\xi J_{t+1} = (1-\xi)\left(W_{t+1}^p - U_{t+1}\right)$, (3.F14) can be written as

$$W_t^p - U_t = w_t^p h_t^p - \psi \frac{\left(h_t^p\right)^{1+\varsigma}}{\varphi_t (1+\varsigma)} - z_t + \beta \left(1 - \lambda^p - p_t^p\right) \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} \frac{\xi}{1-\xi} (J_{t+1}) \quad (3.F16)$$

as $\frac{\iota^p}{q_t^p} = \beta \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} (J_{t+1})$, so

$$J_t = y_t^p - w_t^p h_t^p - r_t^p k_t^p + (1-\lambda^p) \frac{\iota^p}{q_t^p} \quad (3.F17)$$

Combining (3.F17) and (3.F16) delivers the surplus

$$S_t = y_t^p - r_t^p k_t^p - \psi \frac{\left(h_t^p\right)^{1+\varsigma}}{\varphi_t (1+\varsigma)} - z_t + (1-\lambda^p) \frac{\iota^p}{q_t^p} + \left(1 - \lambda^p - p_t^p\right) \frac{\xi}{1-\xi} \frac{\iota^p}{q_t^p} \quad (3.F18)$$

Proof of Equations (3.27) **and** (3.28)

From (3.25) and (3.26), as

$$W_t^p - U_t = w_t^p h_t^p - \psi \frac{\left(h_t^p\right)^{1+\varsigma}}{\varphi_t (1+\varsigma)} - z_t + \left(1 - \lambda^p - p_t^p\right) \frac{\xi}{1-\xi} \frac{\iota^p}{q_t^p} \quad (3.F19)$$

and

$$\xi S_t = \xi \left\{ y_t^p - r_t^p k_t^p - \psi \frac{\left(h_t^p\right)^{1+\varsigma}}{\varphi_t (1+\varsigma)} - z_t + (1-\lambda^p) \frac{\iota^p}{q_t^p} + \left(1 - \lambda^p - p_t^p\right) \frac{\xi}{1-\xi} \frac{\iota^p}{q_t^p} \right\} \quad (3.F20)$$

equalizing (3.F19) with (3.F20), and combining common terms deliver

$$w_t^p h_t^p = \xi \left(y_t^p - r_t^p k_t^p + \iota^p \frac{v_t^p}{u_t^p} \right) + (1-\xi) \left[\psi \frac{\left(h_t^p\right)^{1+\varsigma}}{\varphi_t (1+\varsigma)} + z_t \right] \quad (3.F21)$$

The the FOC w.r.t private hours worked is

$$\text{LHS} = \xi \left(W_t^p - U_t^p\right)^{\xi-1} (J_t - V_t)^{1-\xi} \frac{\partial W_t^p}{\partial h_t^p} \tag{3.F22}$$

$$\text{RHS} = -(1-\xi)\left(W_t^p - U_t^p\right)^{\xi} (J_t - V_t)^{-\xi} \frac{\partial J_t}{\partial h_t^p} \tag{3.F23}$$

Simplifying delivers

$$\xi J_t \frac{\partial W_t^p}{\partial h_t^p} = -(1-\xi)\left(W_t^p - U_t\right) \frac{\partial J_t}{\partial h_t^p} \tag{3.F24}$$

as $\xi J_t = (1-\xi)\left(W_t^p - U_t\right)$, thus hours supplied is $\frac{\partial W_t^p}{\partial h_t^p} = -\frac{\partial J_t}{\partial h_t^p}$. Since $\frac{\partial W_t^p}{\partial h_t^p} = w_t^p - \psi \frac{\left(h_t^p\right)^{\varsigma}}{\varphi_t}$, and $\frac{\partial J_t}{\partial h_t^p} = a_t (1-\alpha_p)\left(k_t^p\right)^{\alpha_p}\left(h_t^p\right)^{-\alpha_p}\left(K_t^g\right)^{\alpha_g} - w_t^p$, thus

$$a_t (1-\alpha_p)\left(k_t^p\right)^{\alpha_p}\left(h_t^p\right)^{-\alpha_p}\left(K_t^g\right)^{\alpha_g} = \psi \frac{\left(h_t^p\right)^{\varsigma}}{\varphi_t} \tag{3.F25}$$

3.G The Nonlinear Equations

The labor market:

$$n_t^p + n_t^g + u_t = 1. \tag{3.G1}$$

$$n_t^p = \eta^p \left(u_{t-1}^p\right)^{\mu^p} \left(v_{t-1}^p\right)^{1-\mu^p} + (1-\lambda^p)\, n_{t-1}^p \tag{3.G2}$$

$$n_t^g = \eta^g \left(u_{t-1}^g\right)^{\mu^g} \left(v_{t-1}^g\right)^{1-\mu^g} + (1-\lambda^g)\, n_{t-1}^g \tag{3.G3}$$

$$u_t^p = (1-s_t)\, u_t \tag{3.G4}$$

$$u_t^g = s_t u_t \tag{3.G5}$$

$$\frac{m_t^p \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} \Delta_{t+1}^p}{1-s_t} = \frac{m_t^g \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} \Delta_{t+1}^g}{s_t} \tag{3.G6}$$

Define $\Delta_t^p = W_t^p - U_t$, $\Delta_t^g = W_t^g - U_t$, then

$$\Delta_t^p = w_t^p h_t^p - \psi \frac{\left(h_t^p\right)^{1+\varsigma}}{\varphi_t (1+\varsigma)} - z_t + \beta \left(1 - \lambda^p - p_t^p\right) \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} \Delta_{t+1}^p \tag{3.G7}$$

$$\Delta_t^g = w_t^g h_t^g - \psi \frac{\left(h_t^g\right)^{1+\varsigma}}{\varphi_t (1+\varsigma)} - z_t + \beta \left(1 - \lambda^g - p_t^g\right) \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} \Delta_{t+1}^g \tag{3.G8}$$

$$m_t^p = \eta^p \left(u_t^p\right)^{\mu^p} \left(v_t^p\right)^{1-\mu^p} \tag{3.G9}$$

$$m_t^g = \eta^g \left(u_t^g\right)^{\mu^g} \left(v_t^g\right)^{1-\mu^g} \tag{3.G10}$$

$$\frac{\iota^p v_t^p}{m_t^p} = \beta \mathbb{E}_t \frac{\varphi_{t+1}}{\varphi_t} \left[y_{t+1}^p - w_{t+1}^p h_{t+1}^p - r_{t+1}^p k_{t+1}^p + \left(1-\lambda^p\right) \frac{\iota^p v_{t+1}^p}{m_{t+1}^p} \right] \tag{3.G11}$$

$$q_t^p = \frac{m_t^p}{v_t^p} = \eta^p \left(u_t^p\right)^{\mu^p} \left(v_t^p\right)^{-\mu^p} \tag{3.G12}$$

$$q_t^g = \frac{m_t^g}{v_t^g} = \eta^g \left(u_t^g\right)^{\mu^g} \left(v_t^g\right)^{-\mu^g} \tag{3.G13}$$

$$p_t^p = \frac{m_t^p}{u_t^p} = \eta^p \left(u_t^p\right)^{\mu^p-1} \left(v_t^p\right)^{1-\mu^p} \tag{3.G14}$$

$$p_t^g = \frac{m_t^g}{u_t^g} = \eta^g \left(u_t^g\right)^{\mu^g-1} \left(v_t^g\right)^{1-\mu^g} \tag{3.G15}$$

$$w_t^p h_t^p = \xi \left(y_t^p - r_t^p k_t^p + \iota^p \frac{v_t^p}{u_t^p} \right) + (1-\xi) \left[\psi \frac{\left(h_t^p\right)^{1+\varsigma}}{\varphi_t \left(1+\varsigma\right)} + z_t \right] \tag{3.G16}$$

$$\psi \frac{\left(h_t^p\right)^{\varsigma}}{\varphi_t} = a_t^p \left(1-\alpha_p\right) \left(k_t^p\right)^{\alpha_p} \left(h_t^p\right)^{-\alpha_p} \left(K_t^g\right)^{\alpha_g} \tag{3.G17}$$

The household

$$Y_t = c_t^p + I_t^p + w_t^g n_t^g h_t^g + I_t^g + g_t^g + u_t z_t + v_t^p \iota^p \tag{3.G18}$$

$$\beta \mathbb{E}_t \varphi_{t+1} \left(1 + r_{t+1}^p - \delta^p\right) = \varphi_t \tag{3.G19}$$

$$K_t^p = n_t^p k_t^p \tag{3.G20}$$

$$K_{t+1}^p = I_t^p + (1-\delta^p) K_t^p \tag{3.G21}$$

$$\left[\phi \left(c_t^p\right)^{\frac{\zeta-1}{\zeta}} + (1-\phi) \left(c_t^g\right)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{1-\sigma\zeta}{\zeta-1}} \phi \left(c_t^p\right)^{\frac{-1}{\zeta}} = \varphi_t \tag{3.G22}$$

The firm

$$a_t^p \alpha_p \left(k_t^p\right)^{\alpha_p-1} \left(h_t^p\right)^{1-\alpha_p} \left(K_t^g\right)^{\alpha_g} = r_t^p \tag{3.G23}$$

$$y_t^p = a_t^p \left(k_t^p\right)^{\alpha_p} \left(h_t^p\right)^{1-\alpha_p} \left(K_t^g\right)^{\alpha_g} \tag{3.G24}$$

$$Y_t = n_t^p y_t^p \tag{3.G25}$$

The government

$$y_t^g = a_t^g \left(K_t^g\right)^{\gamma} \left(n_t^g h_t^g\right)^{1-\gamma} \tag{3.G26}$$

$$w_t^g = (1+\pi^g) w_t^p \tag{3.G27}$$

$$c_t^g = a_t^g \left(K_t^g\right)^{\gamma} \left(n_t^g h_t^g\right)^{1-\gamma} - \iota^g v_t^g \tag{3.G28}$$

$$K_{t+1}^g = (1-\delta^g) K_t^g + I_t^g \tag{3.G29}$$

The AR(1) processes

$$h_t^g = \left(\bar{h}^g\right)^{1-\rho_{hg}} \left(h_{t-1}^g\right)^{\rho_{hg}} e^{\varepsilon_t^{hg}} \tag{3.G30}$$

$$I_t^g = \left(\bar{I}^g\right)^{1-\rho_{Ig}} \left(I_{t-1}^g\right)^{\rho_{Ig}} e^{\varepsilon_t^{Ig}} \tag{3.G31}$$

$$g_t^g = \left(\bar{g}^g\right)^{1-\rho_{gg}} \left(g_{t-1}^g\right)^{\rho_{gg}} e^{\varepsilon_t^{gg}} \tag{3.G32}$$

There are 29 equations and 29 endogenous variables q_t^p, q_t^g, n_t^g, u_t, h_t^p, s_t, Δ_t^p, Δ_t^g, w_t^p, k_t^p, y_t^p, K_t^p, I_t^p, Y_t, w_t^g, y_t^g, c_t^g, c_t^p, φ_t, u_t^p, u_t^g, m_t^p, m_t^g,v_t^p, p_t^p,p_t^g, r_t^p, w_t^g, K_t^g; in addition, there are three AR(1) processes that govern the three exogenous variables.

3.H The Steady State

$$n^p = 1 - n^g - u. \tag{3.H1}$$

$$n^p = \eta^p \left(u^p\right)^{\mu^p} \left(v^p\right)^{1-\mu^p} + \left(1 - \lambda^p\right) n^p \tag{3.H2}$$

$$n^g = \eta^g \left(u^g\right)^{\mu^g} \left(v^g\right)^{1-\mu^g} + \left(1 - \lambda^g\right) n^g \tag{3.H3}$$

$$u^p = (1 - s)\, u \tag{3.H4}$$

$$u^g = su \tag{3.H5}$$

$$\frac{m^p \mathbb{E} \frac{\varphi}{\varphi} \Delta^p}{1 - s} = \frac{m^g \mathbb{E} \frac{\varphi}{\varphi} \Delta^g}{s} \tag{3.H6}$$

$$\Delta^p = w^p h^p - \psi \frac{\left(h^p\right)^{1+\varsigma}}{\varphi\,(1+\varsigma)} - z + \beta\left(1 - \lambda^p - p^p\right) \mathbb{E} \frac{\varphi}{\varphi} \Delta^p \tag{3.H7}$$

$$\Delta^g = w^g h^g - \psi \frac{\left(h^g\right)^{1+\varsigma}}{\varphi\,(1+\varsigma)} - z + \beta\left(1 - \lambda^g - p^g\right) \mathbb{E} \frac{\varphi}{\varphi} \Delta^g \tag{3.H8}$$

$$m^p = \eta^p \left(u^p\right)^{\mu^p} \left(v^p\right)^{1-\mu^p} \tag{3.H9}$$

$$m^g = \eta^g \left(u^g\right)^{\mu^g} \left(v^g\right)^{1-\mu^g} \tag{3.H10}$$

$$\frac{\iota^{p} v^{p}}{m^{p}} = \beta \mathbb{E}_{t} \frac{\varphi}{\varphi} \left[y^{p} - w^{p} h^{p} - r^{p} k^{p} + (1 - \lambda^{p}) \frac{\iota^{p} v^{p}}{m^{p}} \right] \tag{3.H11}$$

$$q^{p} = \eta^{p} (u^{p})^{\mu^{p}} (v^{p})^{-\mu^{p}} \tag{3.H12}$$

$$q^{g} = \frac{m^{g}}{v^{g}} = \eta^{g} (u^{g})^{\mu^{g}} (v^{g})^{-\mu^{g}} \tag{3.H13}$$

$$p^{p} = \eta^{p} (u^{p})^{\mu^{p}-1} (v^{p})^{1-\mu^{p}} \tag{3.H14}$$

$$p^{g} = \eta^{g} (u^{g})^{\mu^{g}-1} (v^{g})^{1-\mu^{g}} \tag{3.H15}$$

$$w^{p} h^{p} = \xi \left(y^{p} - r^{p} k^{p} + \iota^{p} \frac{v^{p}}{u^{p}} \right) + (1 - \xi) \left[\psi \frac{(h^{p})^{1+\varsigma}}{\varphi (1 + \varsigma)} + z \right] \tag{3.H16}$$

$$\psi \frac{(h^{p})^{\varsigma}}{\varphi} = a^{p} (1 - \alpha_{p}) (k^{p})^{\alpha_{p}} (h^{p})^{-\alpha_{p}} (K^{g})^{\alpha_{g}} \tag{3.H17}$$

$$Y = c^{p} + I^{p} + w^{g} n^{g} h^{g} + I^{g} + g^{g} + uz + v^{p} \iota^{p} \tag{3.H18}$$

$$\beta \mathbb{E} \varphi (1 + r^{p} - \delta^{p}) = \varphi \tag{3.H19}$$

$$K^{p} = n^{p} k^{p} \tag{3.H20}$$

$$K^{p} = I^{p} + (1 - \delta^{p}) K^{p} \tag{3.H21}$$

$$\left[\phi\left(c^{p}\right)^{\frac{\zeta-1}{\zeta}}+(1-\phi)\left(c^{g}\right)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{1-\sigma\zeta}{\zeta-1}}\phi\left(c^{p}\right)^{\frac{-1}{\zeta}}=\varphi \tag{3.H22}$$

$$a^{p}\alpha_{p}\left(k^{p}\right)^{\alpha_{p}-1}\left(h^{p}\right)^{1-\alpha_{p}}\left(K^{g}\right)^{\alpha_{g}}=r^{p} \tag{3.H23}$$

$$y^{p}=a^{p}\left(k^{p}\right)^{\alpha_{p}}\left(h^{p}\right)^{1-\alpha_{p}}\left(K^{g}\right)^{\alpha_{g}} \tag{3.H24}$$

$$Y=n^{p}y^{p} \tag{3.H25}$$

$$y^{g}=a^{g}\left(K^{g}\right)^{\gamma}\left(n^{g}h^{g}\right)^{1-\gamma} \tag{3.H26}$$

$$w^{g}=\left(1+\pi^{g}\right)w^{p} \tag{3.H27}$$

$$c^{g}=a^{g}\left(K^{g}\right)^{\gamma}\left(n^{g}h^{g}\right)^{1-\gamma}-\iota^{g}v^{g} \tag{3.H28}$$

$$K^{g}=\left(1-\delta^{g}\right)K^{g}+I^{g} \tag{3.H29}$$

$$h^{g}=\bar{h}^{g} \tag{3.H30}$$

$$I^{g}=\bar{I}^{g} \tag{3.H31}$$

$$g^{g}=\bar{g}^{g} \tag{3.H32}$$

3.I The Fiscal Multipliers

Following Spilimbergo et al. (2009), Chinn (2013), the fiscal output/unemployment multiplier is defined as the ratio of a change in output ΔGDP or unemployment rate Δu to an exogenous change in the government wage expenditure ΔGWE, government investment ΔGIE, and government consumption expenditure ΔGCE with respect to their respective steady state values.

In our paper, we report the following four types of output/unemployment multipliers:

The *impact multiplier*: $\frac{\Delta GDP(t)}{\Delta GS(t)}, \frac{\Delta u(t)}{\Delta GS(t)}$;

The *impact multiplier at quarter Q*: $\frac{\Delta GDP(t+Q)}{\Delta GS(t)}, \frac{\Delta u(t+Q)}{\Delta GS(t)}$;

The *peak impact multiplier*: $\max_Q \frac{\Delta GDP(t+Q)}{\Delta GS(t)}, \max_Q \frac{\Delta u(t+Q)}{\Delta GS(t)}$;

The *cumulative multiplier*[24], which is the ratio of the cumulative change in output/unemployment rate to the cumulative change in the government wage expenditure ΔGWE, government investment ΔGIE, and government consumption expenditure ΔGCE within certain quarter Q: $\frac{\sum_{q=0}^{q=Q} \Delta GDP(t+q)}{\sum_{q=0}^{q=Q} \Delta GS(t+q)}, \frac{\sum_{q=0}^{q=Q} \Delta u(t+q)}{\sum_{q=0}^{q=Q} \Delta GS(t+q)}$, where $\Delta GS = \{\Delta GWE, \Delta GIE, \Delta GCE\}$, $Q = 0, 1, 2, \cdots, 40$.

[24]Uhlig (2010) and Mountford and Uhlig (2009) employ the resent value cumulative multiplier in their studies, the only difference is that they discount future changes using the discount factor, in terms of the magnitude of fiscal multipliers, the method proposed by Spilimbergo et al. (2009), Monacelli et al. (2010), and Chinn (2013) are slightly larger because of no discounting.

3.J The Social Planner's Problem

The social planner's problem is to maximize (3.8) subject to (3.1), (3.2), (3.4), (3.20), (3.30), (3.10), and (3.31).

The Lagrangian is

$$
\begin{aligned}
\mathscr{L}_s \; = \; & \sum_{j=0}^{\infty} \beta^{t+j} \Bigg\{ \frac{\left(c_{t+j}^{\frac{\zeta}{\zeta-1}} \right)^{1-\sigma} - 1}{1-\sigma} - \psi n_{t+j}^{p} \frac{\left(h_{t+j}^{p}\right)^{1+\varsigma}}{1+\varsigma} - \psi n_{t+j}^{g} \frac{\left(h_{t+j}^{g}\right)^{1+\varsigma}}{1+\varsigma} \\
& + \Lambda_{t+j}^{1} \left[\eta^{p} \left((1-s_{t+j}) \left(1 - n_{t+j}^{p} - n_{t+j}^{g}\right)\right)^{\mu^{p}} \left(v_{t+j}^{p}\right)^{1-\mu^{p}} + (1-\lambda^{p}) n_{t+j}^{p} - n_{t+j+1}^{p} \right] \\
& + \Lambda_{t+j}^{2} \left[\eta^{g} \left(s_{t+j} \left(1 - n_{t+j}^{p} - n_{t+j}^{g}\right)\right)^{\mu^{g}} \left(v_{t+j}^{g}\right)^{1-\mu^{g}} + (1-\lambda^{g}) n_{t+j}^{g} - n_{t+j+1}^{g} \right] \\
& + \Lambda_{t+j}^{3} \left[I_{t+j}^{p} + (1-\delta^{p}) n_{t+j}^{p} k_{t+j}^{p} - n_{t+j+1}^{p} k_{t+j+1}^{p} \right] \\
& + \Lambda_{t+j}^{4} \left[(1-\delta^{g}) K_{t+j}^{g} + I_{t+j}^{g} - K_{t+j+1}^{g} \right] \Bigg\}
\end{aligned}
$$

The first order conditions are characterized by:

$$
v_t^p:\; \underbrace{c_{t+1}^{\frac{1-\sigma\zeta}{\zeta-1}} \phi \left(\Pi_t\right)^{\frac{-1}{\zeta}} \iota^{p}}_{MC_{v^p}} = \underbrace{\Lambda_t^{1} \left(1-\mu^{p}\right) \frac{m_t^{p}}{v_t^{p}}}_{MB_{v^p}}
$$

$$
v_t^g:\; \underbrace{c_{t+1}^{\frac{1-\sigma\zeta}{\zeta-1}} (1-\phi) \left(c_t^{g}\right)^{\frac{-1}{\zeta}} \iota^{g}}_{MC_{v^g}} = \underbrace{\Lambda_t^{2} \left(1-\mu^{g}\right) \frac{m_t^{g}}{v_t^{g}}}_{MB_{v^g}}
$$

$$
h_t^p:\; \underbrace{c_{t+1}^{\frac{1-\sigma\zeta}{\zeta-1}} \phi \left(\Pi_t\right)^{\frac{-1}{\zeta}} \left[(1-\alpha_p) \frac{y_t^{p}}{h_t^{p}} - w_t^{p} \right]}_{MB_{h^p}} = \underbrace{\psi \left(h_t^{p}\right)^{\varsigma}}_{MC_{h^p}}
$$

$$
h_t^g:\; \underbrace{c_{t+1}^{\frac{1-\sigma\zeta}{\zeta-1}} (1-\phi) \left(c_t^{g}\right)^{\frac{-1}{\zeta}} (1-\gamma) \frac{y_t^{g}}{h_t^{g}}}_{MB_{h^g}} = \underbrace{\psi \left(h_t^{g}\right)^{\varsigma}}_{MC_{h^g}}
$$

$$s_t\colon \underbrace{\frac{\Lambda_t^1 \mu^p m_t^p}{1-s_t}}_{MB_{s1}} = \underbrace{\frac{\Lambda_t^2 \mu^g m_t^g}{s_t}}_{MB_{s2}}$$

n_{t+1}^p:

$$\underbrace{\Lambda_t^1}_{MC_{n^p}} = \underbrace{\beta\left\{c_{t+1}^{\frac{1-\sigma\zeta}{\zeta-1}} \phi\left(\Pi_{t+1}\right)^{\frac{-1}{\zeta}} \pi_{t+1}^p - \psi\frac{\left(h_{t+1}^p\right)^{1+\varsigma}}{1+\varsigma} + \Lambda_{t+1}^1\left[\left(1-\lambda^p\right) - \mu^p\frac{m_{t+1}^p}{u_{t+1}^p}\right] - \Lambda_{t+1}^2\mu^g\frac{m_{t+1}^g}{u_{t+1}^g}\right\}}_{MB_{n^p}}$$

n_{t+1}^g:

$$\underbrace{\Lambda_t^2}_{MC_{n^g}} = \underbrace{\beta\left\{c_{t+1}^{\frac{1-\sigma\zeta}{\zeta-1}} \left(1-\phi\right)\left(c_{t+1}^g\right)^{\frac{-1}{\zeta}} \pi_{t+1}^g - \psi\frac{\left(h_{t+1}^g\right)^{1+\varsigma}}{1+\varsigma} - \Lambda_{t+1}^1\mu^p\frac{m_{t+1}^p}{u_{t+1}^p} + \Lambda_{t+1}^2\left[\left(1-\lambda^g\right) - \mu^g\frac{m_{t+1}^g}{u_{t+1}^g}\right]\right\}}_{MB_{n^g}}$$

$$k_{t+1}^p\colon \underbrace{\Lambda_t^3}_{MC_{k^p}} = \underbrace{\beta\left\{c_{t+1}^{\frac{1-\sigma\zeta}{\zeta-1}} \phi\left(\Pi_{t+1}\right)^{\frac{-1}{\zeta}} mp_{k_{t+1}} + \Lambda_{t+1}^3\left(1-\delta^p\right)n_{t+1}^p\right\}}_{MB_{k^p}}$$

$$K_{t+1}^g\colon \underbrace{\Lambda_t^4}_{MC_{K^g}} = \underbrace{\beta\left\{c_{t+1}^{\frac{1-\sigma\zeta}{\zeta-1}} \left(1-\phi\right)\left(c_t^g\right)^{\frac{-1}{\zeta}} mp_{K_{t+1}} + \Lambda_{t+1}^4\left(1-\delta^g\right)\right\}}_{MB_{K^g}}$$

where

$$c_{t+j} = \phi\left(\Pi_{t+j}\right)^{\frac{\zeta-1}{\zeta}} + \left(1-\phi\right)\left(c_{t+j}^g\right)^{\frac{\zeta-1}{\zeta}},$$

$$\pi_{t+1}^p = y_{t+1}^p - w_{t+1}^p h_{t+1}^p - r_{t+1}^p k_{t+1}^p,$$

$$\pi_{t+1}^g = \left(1-\gamma\right) a_{t+1}^g \left(K_{t+1}^g\right)^{\gamma}\left(h_{t+1}^g\right)^{1-\gamma}\left(n_{t+1}^g\right)^{-\gamma},$$

$$mp_{k_{t+1}} = \alpha_p a_{t+1}^p \left(n_{t+1}^p k_{t+1}^p\right)^{\alpha_p-1}\left(n_{t+1}^p h_{t+1}^p\right)^{1-\alpha_p}\left(K_{t+1}^g\right)^{\alpha_g} n_{t+1}^p - r_{t+1}^p n_{t+1}^p,$$

$$mp_{K_{t+1}} = \gamma a_{t+j}^g \left(K_{t+j}^g\right)^{\gamma-1}\left(n_{t+j}^g h_{t+j}^g\right)^{1-\gamma},$$

$$\Pi_{t+j} = \left[a_{t+j}^p\left(k_{t+j}^p\right)^{\alpha_p}\left(h_{t+j}^p\right)^{1-\alpha_p}\left(K_{t+j}^g\right)^{\alpha_g} - w_{t+j}^p h_{t+j}^p - r_{t+j}^p k_{t+j}^p\right] n_{t+j}^p - \iota^p v_{t+j}^p,$$

$$c^g_{t+j} = a^g_{t+j}\left(K^g_{t+j}\right)^{\gamma}\left(n^g_{t+j}h^g_{t+j}\right)^{1-\gamma} - \iota^g v^p_{t+j}.$$

These FOCs characterize the optimal private and public sector vacancies v^p_t and v^g_t, optimal private and public hours worked h^p_t and h^g_t, the optimal share of unemployed searching in the public sector s_t, the optimal private and public employment n^p_{t+1} and n^g_{t+1}, the optimal private and public physical capital holdings k^p_{t+1} and k^g_{t+1}, respectively.

Chapter 4

Fiscal Policy Changes and Labor Market Dynamics in Japan's Lost Decade

The unemployment rate surged from 2.08% in 1990 to 5.40% in 2002 in Japan. Meanwhile, the Japanese economy experienced changes in the share of government wage, consumption, investment, and different categories of taxes, respectively. This chapter quantitatively evaluates the impacts of these changes in fiscal policies on labor market variables, in particular, the unemployment rate, during the Lost Decade. We build, calibrate, and simulate a dynamic general equilibrium model with search and matching frictions in the labor market, a productive government sector, heterogenous government spending, and different categories of taxes. Our model is able to reproduce the path of main labor market variables, and the counterfactual experiments show that changes in different spending components affect the unemployment rate heterogeneously, while a 10% reduction in labor tax reduces the unemployment rate by 15.87%, during the Lost Decade in Japan. Our quantitative study confirms that countercyclical fiscal policies contribute to cushion the labor market in the 1990s.

4.1 Introduction

The Lost Decade indicates the 1990s in Japan, a period with many structural changes[1]. The average growth rate of output per capita was 0.50%, much lower than the average of the 1980s, 3.20%, and that of the U.S. during the same era, 2.60% Esteban-Pretel et al. (2010). The detrended total factor productivity (TFP) had declined by more than 10%. Meanwhile, the unemployment rate in Japan surged from 2.08% in 1990 to 5.40% in 2002. Underlying this significant increase in unemployment, the job finding probability decreased from 42% to 27% and the probability of losing a job increased from 0.80% to 1.87% during the Lost Decade, respectively. The deteriorating labor market experience during the Lost Decade has been concerned by many researchers.

To alleviate the experiences in the labor market in the 1990s, the Japanese government changed their fiscal policies to boost the economy and to cushion its labor market. From the aspect of government expenditures, the share of aggregate government spending in gross national product (GNP) increases by more than 20% from 1990 to 2002, as shown in Figure 4.1g. In particular, underlying this significant increase in the share of total government expenditure, there are heterogenous changes in different spending components, as shown in Figure 4.1h: the share of government wage expenditure[2] rises from 6.18% to 6.65%, the share of government consumption increases from 7.71% to 11.10%, and the share of government investment actually reduces from 6.35% to 6.32%, respectively, from 1990 to 2002.

From the perspective of government taxes, the Japanese government raised the proportional consumption tax from 0.03 to 0.05 in 1997. Meanwhile, according to Mendoza

[1]For example, according to Houseman and Osawa (2003), the share of part-time jobs significantly increased, about 30% of the Japanese workers were classified as part-time by their employers.

[2]Note that when we mention the shares of government wage, investment, and consumption later in this paper, we mean they are the shares of government wage, investment, and consumption in GNP, rather than those in total government spending.

et al. (1994) and Esteban-Pretel et al. (2010), the proportional labor income tax rate was fairly stable in the 1990s, and the changes in proportional capital income tax was also very small over the Lost Decade.

The main target of this paper is to evaluate the impacts of the aforementioned changes in fiscal policies on labor market variables. In particular, we focus on the heterogeneous effects of different fiscal policy instruments on the unemployment rate during the Lost Decade in Japan. The reason we concentrate on the heterogeneous aspects of different fiscal policy instruments is because we want to understand what is the most effective policy instrument to stimulate the economy, i.e., to reduce the unemployment rate during the 1990s.

To achieve this objective, we build, calibrate, and simulate a dynamic general equilibrium model with search and matching frictions in the labor market à la Mortensen and Pissarides (1994). We extended the framework of a standard discrete time neo-classical growth model with two sectors: a private sector and a productive government sector. It is extremely important to model the public sector explicitly because government wage expenditure and government investment which consist of a significant fraction of the total government spending play different roles in stimulating the economy. Therefore, to understand how different components affect the aggregate economy heterogeneously, we need to model a productive government sector employing labor and capital explicitly.

In the model with a productive government sector, the roles of different spending components are explicitly characterized: government wage spending directly affects the goods produced in the public sector, government investment affects the public production via the accumulation of public physical capital, and government consumption affects aggregate demand as in the standard model but it is nonproductive. In addition, three categories of taxes with different characters are also introduced through assuming that government impose proportional labor tax, capital tax, and consumption tax to finance its spending: labor tax affects the value of being employed, capital tax influences the capital accumulation, while consumption tax affects the wealth of the household.

The model is calibrated to match the data moment of the Japanese economy in 1990, which is the beginning of the Lost Decade. As in Esteban-Pretel et al. (2010), through employing the solution method of a two-boundary problem, we solve and simulate the transition path of the economy from an initial steady state, i.e., 1990, to a new steady state far away in the future. The decline in total factor productivity (TFP), the changes in government wage, consumption, and investment, and the reduction in hours worked together drive the transition from the initial steady state to the new steady state. We find that our model is able to reproduce the changes in the main labor market variables, in particular, the increase in unemployment, from 1990 to 2002. As far as we know, this is the first paper that employs a two-sector framework with search frictions and rich specifications of fiscal policies, to investigate the impacts of changes in fiscal policies on labor market dynamics in the 1990s of Japan, which is one of our contributions in this study.

With the calibrated model, we quantitatively evaluate the potential impacts of changes in fiscal policies on unemployment during the Lost Decade through conducting two categories of counterfactual experiments. We first evaluate the changes in different government spending components on the unemployment rate in the 1990s through fixing the share of government wage, consumption, and investment at their 1990's level, respectively. We find that the unemployment rate in 2002 would be 7.56% and 0.36% lower, respectively, if government investment and wage didn't decrease, while the unemployment rate in 2002 would be 5.90% higher if government consumption did not increase. The intuition is that increasing government spending is accompanied by rising taxes, leading to decreases in household wealth, which increases in the value of being employed, and decreases in the value of being unemployed, so matching surplus increases, which encourages vacancy posting, hiring, and thus unemployment decreases. Decreasing government spending works in a similar mechanism but in opposite directions.

Then we evaluate the potential impacts of changes in various categories of tax rates on the unemployment rate during the Lost Decade via reducing labor tax, capital tax, and consumption tax by 10% each after 1990 and staying at that level during the 1990s, respectively. Through simulations, we find that the unemployment rate in 2002 reduces by 15.87% if government adopted labor tax reduction, the intuition is that reducing labor tax directly increases the value of being employed, leading to increases in matching surplus and hence encourages vacancy posting, hiring, and employment. Moreover, if capital tax was reduced by 10%, the unemployment rate in 2002 reduces by 9.59%, the reason is that reducing capital tax increases the future capital stock, the marginal product of labor, and the surplus of matching, which provides higher incentive to post vacancies and hire people, thus unemployment decreases. In addition, the unemployment in 2002 decreases by 13.83% if government reduced the consumption tax by 10%, the intuition is that reducing consumption tax implies that the disposable income of household increases, leading to decrease in the shadow value of wealth and decline in the equilibrium interest rate, so capital accumulation and the present value of future vacancies increases, which encourages vacancy posting and reduces unemployment.

The reminder of this paper is organized as follows. Section 4.2 briefly reviews the related literature and clearly states our contributions in this study. Section 4.3 documents the stylized facts concerning the Japanese labor market and fiscal policy changes during the 1990s. In section 4.4, we develop a discrete time neo-classical growth model with search frictions and a productive government sector with rich specifications of fiscal policies. The model is calibrated in section 4.5. Section 4.6 reports the benchmark simulation results. In section 4.7, we examine the impacts of changes in fiscal policy on unemployment through conducting counterfactual experiments. Section 4.8 concludes and discusses the research directions of this paper.

4.2 Literature Review

Our paper is related to the stream of recent literature that quantitatively evaluates the impacts of expansionary fiscal policy on labor market dynamics. Kuo and Miyamoto (2014), Bruckner and Pappa (2012), and Monacelli et al. (2010) evaluated the dynamic effects of fiscal policy on labor market variables in U.S. through developing a dynamic stochastic general equilibrium model with search and matching frictions as in Mortensen and Pissarides (1994), which was pioneered by Merz (1995) and Andolfatto (1996), and found that expansionary fiscal policy boosted output and reduced unemployment during recessions. Employing the similar framework, Kato and Miyamoto (2013) and Kato and Miyamoto (2015) quantitatively evaluates the dynamic effects of fiscal policy, in particular, government spending, on labor market variables in Japan with the data from 1980Q1 to 2010Q1. They find that expansionary government spending reduces unemployment, increases job finding probability, and decreases job separation probability.

A common feature of this stream of literature is that their model environment is stochastic, they can only examine whether the effects of unexpected changes in government spending on output and unemployment are positive or negative, and how large are these effects. However, these models could not be employed to evaluate what would be the unemployment rate precisely at a specific point in time if government changes its fiscal policy during a certain period of time. To answer this type of question, we develop a dynamic general equilibrium model with search frictions in a deterministic environment as in Esteban-Pretel et al. (2010), which is further extended with a richer specification of fiscal policies, so as to quantitatively examine the impacts of fiscal policy changes on labor market variables during the Lost Decade in Japan, which is another contribution of our study to the existing literature.

Our paper is also related to another stream of literature exploring the causes, consequences, and policies related to the poor performance of the Japanese economy in the 1990s, such as Hayashi and Prescott (2002), Peek and Rosengren (2005), Caballero et al.

(2008), and Esteban-Pretel et al. (2010). As the target of our paper is to examine how changes in fiscal policies affect the labor market dynamics during the Lost Decade, we don't pay special attention to the causes and consequences of the 1990s, our paper concentrates on examining the labor market effects of changes in fiscal policy in the Lost Decade of Japan.

Krugman et al. (1998) and Eggertsson and Woodford (2003) point out that the Japanese economy fell into a liquidity trap in the 1990s, which restricts the effectiveness of monetary policy to come into effect, and the impacts of fiscal policy are particularly interested by economist under this scenario (e.g., Werning, 2011; and Blanchard et al., 2010). However, there is quite few study investigated the characters of fiscal policy during the 1990s of Japan. As far as we know, our paper is the first paper that quantitatively evaluates the impacts of changes in fiscal policies on the labor market dynamics in the 1990s of Japan, which is the third contribution to the literature.

Out of the literature, our paper is closely related to Esteban-Pretel et al. (2010). However, this paper differs from theirs in several aspects: First, our target is to examine the effects of fiscal policy changes on unemployment in the 1990s, while Esteban-Pretel et al. (2010) tries to explain the behavior and causes of the labor market performances during the Lost Decade. Second, since two papers have different targets, our paper employs a two-sector model with search friction while Esteban-Pretel et al. (2010) uses a one sector model with search frictions. Third, our model has a richer specification of fiscal policies than Esteban-Pretel et al. (2010) to achieve our target in this paper. However, similar to Esteban-Pretel et al. (2010), we also assume exogenous changes in TFP following Hayashi and Prescott (2002) as well as exogenous reductions in hours worked.

4.3 The Stylized Facts in Japan's Lost Decade

The Lost Decade was the worst economic times for Japan since the World War II. According to the stylized facts in Hayashi and Prescott (2002), the level of detrended gross national products (GNP) in 2000 was 90% less than what it had been in 1990. The target of this paper is on the effects of fiscal policy change on unemployment and associated movements in the labor market, therefore, we first explain the characteristics of these variables during the Lost Decade.

Figure 4.1 documents the evolution of total factor productivity (TFP), main labor market variables, the share of aggregate government spending in GNP, and the shares of government wage, consumption, investment in GNP, respectively, from 1990 to 2002[3]. Panel 4.1a shows the evolution of detrended TFP since 1990, where we observe that the detrended TFP declines by more than 10% from 1990 to 2002. Meanwhile, we find that the unemployment rate almost tripled, rising from 2.1% in 1990 to 5.4% in 2002, as shown in Panel 4.1b. This dramatic rising in unemployment is quite striking, as the labor force participation rate was fairly stable during the Lost Decade[4].

As the dynamics of unemployment are determined by the underlying worker flows in the labor market, in particular, the probabilities at which workers finding jobs and lossing jobs. Panel 4.1c and Panel 4.1d show that the job finding probability decreases from 42% in 1990 to 27% in 2002 and the job lossing probability increases from 0.8% to 1.87% during the same period. At the same time, an interesting phenomenon is shown in Panel 4.1e and Panel 4.1f, i.e., both the total number of workers who found jobs and the total number of workers who lost jobs increases from 0.87% to 1.47% and from 0.79% to 1.77%, respectively. Unemployment increased because the total number of workers moving into unemployment was higher than that of workers moving out of unemployment.

[3]Here we follow Esteban-Pretel et al. (2010), where the Lost Decade is defined as 1990 to 2002, because the TFP and main labor market variables either stabilize or reverse their trend after 2002.

[4]According to Esteban-Pretel et al. (2010), the labor force participation rate only changes between 63% and 61% from 1990 to 2002, where the decrease is very small compared with the changes in unemployment during the same period.

In response to the slowdown of economic growth and upsurge of unemployment during the lost decade, the Japanese government increased its aggregate government spending to stimulate the economy and to cushion the labor market, which is demonstrated in Panel 4.1g, where the share of aggregate government expenditure in GNP increased from 20% in 1990 to 24% in 2002. Underlying this substantial 20% increase in the share of aggregate government spending lies heterogenous movements of its different components shown in Panel 4.1h: the share of government wage expenditure increases by 7.61%, i.e., from 6.18% to 6.65%, the share of government consumption increases by more than 44.97%, i.e., from 7.71% to 11.10%, while the share of government investment actually reduces by 0.47%, i.e., from 6.35% to 6.32% from 1990 to 2002, respectively. These numbers imply that although aggregate share of government spending in GNP increases during the 1990s, the shares of government wage, consumption, and investment are not always moving in the same direction and magnitude, which might generate counteracting impacts on the labor market outcomes.

Meanwhile, the proportional labor income tax and the capital tax were relatively stable, as documented by Mendoza et al. (1994) and Esteban-Pretel et al. (2010). But the consumption tax was raised from 0.03 to 0.05 in 1997. These observations about tax policies imply that during the 1990s, the Japanese government did not adopt contractionary tax policy to cushion the labor market, it is interesting to investigate what would happen to the unemployment rate in the 1990s if government adopted tax reduction policies, such as a 10% reduction in each of the labor, capital, and consumption taxes.

Therefore, the Japanese economy in the 1990s experience a decline in TFP, an increase in unemployment, an upsurge in aggregate government spending, and a fairly stable tax rates in labor, capital, and consumption. We now proceed to build the model employed to examine the impacts of these fiscal policy changes on unemployment dynamics in Japan from 1990 to 2002.

4.4 The Model

The model is a standard discrete time neo-classical growth model[5] augmented with two sectors: a private sector and a productive government sector. Private sector variables are indicated by the superscript p and public sector variables are denoted by g. There are three categories of infinitely lived agents in the economy: households/workers, firms, and government. The labor market in the private sector is modeled following the search and matching literature with endogenous job destruction, while the labor market in the government sector is modeled with exogenous job destruction.

Although the model displays uncertainty at the individual firm and worker level, we assume that there is no uncertainty concerning the aggregate exogenous variables. The individual uncertainty is modeled through an idiosyncratic shock to the match, which leads to the heterogeneity across matches. But this individual uncertainty disappears after the model is aggregated before numerically solving it.

Labor Market

The labor market is modeled such that there exist search and matching frictions, recruiting firms and unemployed workers try to match and form employment relationships. Private sector firms employ private capital, labor, and technology for production, matches in the private sector are endogenously destroyed as an optimal decision by the firm and worker, while matches in the government sector are exogenously destroyed.

The economy-wide labor force is normalized to be 1. At period t, individuals are either private employees (n_t^p), or public employees (n_t^g), or unemployed (u_t), hence

$$n_t^p + n_t^g + u_t = 1. \tag{4.1}$$

The employment relationships are of one unemployed worker to one recruiting firm.

[5]The framework of the discrete time neo-classical growth model here is similar to Cass (1965) and Koopmans (1965).

The number of vacancies posted in sector i is v_t^i, for each $i \in \{p, g\}$. The unemployed workers randomly search across the private sector and government sector, matching occurs according to the standard Cobb-Douglas matching functions

$$m_t = \eta \left(u_t\right)^{\mu} \left(v_t\right)^{1-\mu}, \tag{4.2}$$

where $v_t = v_t^p + v_t^g$. η measures the matching efficiency and μ indicates the elasticity of m_t with respect to u_t at period t. Under random search, there is only one matching function and matches in each sector are determined by the relative vacancies. The ratio of vacancies to unemployed workers are defined as labor market tightness, $\theta_t \equiv \frac{v_t}{u_t}$. The vacancy filling probability q_t, and the sectoral job finding probabilities p_t^i are

$$q_t = \frac{m_t}{v_t}, p_t^i = \frac{m_t}{u_t}\frac{v_t^i}{v_t}, \text{ for each } i \in \{p, g\}. \tag{4.3}$$

The endogenous job destruction in the private sector firms is modeled by assuming that operating firms need to pay, in addition to the labor cost and capital cost, a nonproductive intermediate input cost x_t, which is idiosyncratic to each match. This match-specific intermediate input cost is independent and identically distributed across firms and over time, with distribution function $F : \left[x_{\text{min}}, x_{\text{max}}\right] \rightarrow [0, 1]$. A new idiosyncratic intermediate nonproductive cost is drawn each period by existing matches, the match is endogenously dissolved by the firm and the worker if this cost is too high under the available technology. The threshold value of x_t that dissolves the match is indicated by $\bar{x}_t$, thus the job destruction probability is $1 - F\left(\bar{x}_t\right)$. The matches in the public sector is exogenously destroyed with rate λ^g.

The timing of the model is as follows. At the beginning of each period t, the available technology level is revealed, and every matched firm draws an idiosyncratic intermediate input cost, these two variables together determine the numbers of productive and unproductive matches in period t. The employment and unemployment are determined after destruction takes place, and production starts at the firm. The unemployed and vacancies try to meet in the labor market, at the end of period t, wages are paid and profits are distributed to the household, which pays taxes.

As in the search and matching literature (e.g., Lubik, 2009), the new matches will be productive in one period in both sectors. The evolution of unemployment and employment in each sector is characterized by

$$u_t = \left[1 - p_{t-1}^p F(\bar{x}_t) - p_{t-1}^g\right] u_{t-1} + \left[1 - F(\bar{x}_t)\right] n_{t-1}^p + \lambda^g n_{t-1}^g, \tag{4.4}$$

$$n_t^g = m_{t-1}^g + (1 - \lambda^g) n_{t-1}^g, \tag{4.5}$$

$$n_t^p = m_{t-1}^p + F(\bar{x}_t) n_{t-1}^p. \tag{4.6}$$

where $p_{t-1}^p F(\bar{x}_t) u_{t-1}$ and $p_{t-1}^g u_{t-1}$ are the fractions of unemployed workers who found a successful match at period $t-1$ in the private sector and government sector, respectively. $[1 - F(\bar{x}_t)] n_{t-1}^p$, $\lambda^g n_{t-1}^g$, and $F(\bar{x}_t) n_{t-1}^p$ are the proportion of employed workers who lost their jobs in the private sector, in the public sector, and those who continue their jobs.

Household

Following Merz (1995), the representative household consists of all individuals in the economy. Household members perfectly self-insure each other and thus we don't need to keep tracking of their employment and wealth distributions. The household owns private capital and rents to private firms, and receives wage income from employed family members as well as the unemployment benefits from the unemployed individuals. The household has the following per period utility

$$u(c_t) = \frac{c_t^{1-\sigma} - 1}{1 - \sigma}, \tag{4.7}$$

with

$$c_t = \left[\phi \left(c_t^p\right)^{\frac{\zeta-1}{\zeta}} + (1 - \phi) \left(c_t^g\right)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{\zeta}{\zeta-1}}, \tag{4.8}$$

where c_t is the effective consumption as in Bouakez and Rebei (2007), which is an aggregation of private consumption c_t^p and government goods c_t^g. σ is the inverse of the intertemporal elasticity of substitution. ζ indicates the elasticity of substitution between private consumption and government production. $1-\phi$ measures the degree to which government production affects utility.

The household chooses consumption and savings each period $\left\{c_{t+j}^p, K_{t+1+j}^p\right\}_{j=0}^{\infty}$ and consider $\left\{c_{t+j}^g\right\}_{j=0}^{\infty}$ as given to maximize

$$\sum_{j=0}^{\infty} \beta^j u\left(c_{t+j}\right), \tag{4.9}$$

subject to

$$\begin{aligned}
\left(1+\tau_c\right) c_{t+j}^p + K_{t+1+j}^p \quad = \quad & \left(1-\tau_n\right)\left(W_{t+j}^p + W_{t+j}^g\right) + u_{t+j} s_{t+j} z_{t+j} \\
& + \left(1-\delta^p\right) K_{t+j}^p + r_{t+j}^p K_{t+j}^p - \tau_k \left(r_{t+j}^p - \delta^p\right) K_{t+j}^p \\
& + \Pi_{t+j} - T_{t+j}, \qquad (4.10) \\
& \text{given } K_0.
\end{aligned}$$

for $j = \{0, 1, \ldots, \infty\}$, where $\beta \in (0,1)$, indicates the subjective discount factor of households. W_t^i is the total amount of wages paid to the individuals working in sector i , for each $i \in \{p, g\}$. τ_c is the tax rate on private consumption. τ_n is the tax rate on labor income. τ_k is the capital income tax rate, while only non-depreciated return is taxed. s_t indicates the unemployment benefits or the value of home production. z_t is a variable that grows at the average growth rate of technology. Π_t is the profits from private sector firms. T_t is the lump sum taxes paid by the household. r_t^p is the real rental rate of private capital K_t^p, which depreciates at rate δ^p.

The problem of the household yields the following first order conditions (FOCs)

$$\left[\phi\left(c_t^p\right)^{\frac{\zeta-1}{\zeta}}+(1-\phi)\left(c_t^g\right)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{1-\sigma\zeta}{\zeta-1}}\phi\left(c_t^p\right)^{\frac{-1}{\zeta}} = \varphi_t\left(1+\tau_c\right). \tag{4.11}$$

$$\beta\varphi_{t+1}\left[1+(1-\tau_k)\left(r_{t+1}^p-\delta^p\right)\right] = \varphi_t. \tag{4.12}$$

where φ_t is the marginal utility of private consumption. Equation (4.11) and equation (4.12) together constitute the traditional consumption-Euler equation, implying that the marginal benefit of consuming and the marginal cost of consuming should be equal at the optimal.

Workers

Let $N_t^p(x_t)$ and N_t^g denote the values of being employed and being matched with a firm in the private sector with idiosyncratic input cost x_t and that in a government sector, respectively. Let U_t represent the values of being unemployed.

An unemployed worker receives s_t units of consumption while being unemployed. If the worker matches with a firm in the private sector with probability p_t^p, and the idiosyncratic intermediate input cost for the match x_t is below the destruction threshold $\bar{x}_{t+1}$, he becomes a private sector worker in the next period. If he matches with a firm in the public sector with probability p_t^g, he starts working in the government sector in the following period. If the unemployed does not establish a match with a firm, he remains being unemployed. The value of being unemployed in period t is

$$U_t = s_t z_t+\beta\frac{\varphi_{t+1}}{\varphi_t}\left[p_t^p\int_{x_{min}}^{\bar{x}_{t+1}}N_{t+1}^p\left(x_{t+1}\right)dF\left(x_{t+1}\right)+p_t^g N_{t+1}^g+\left(1-p_t^p F\left(\bar{x}_{t+1}\right)-p_t^g\right)U_{t+1}\right]. \tag{4.13}$$

The value of a match for a worker in the private sector depends on the idiosyncratic intermediate input cost x_t. The workers in the private firm obtains after-tax wage, suffers the disutility of working, and gets the continuation value, which is the value of being employed is the match survives, or the value of being unemployed if the match is destroyed. Therefore, the value of being employed in the private sector in period t is

$$\begin{aligned} N_t^p(x_t) &= (1-\tau_n)\, w_t^p(x_t)\, h_t^p \\ &+\beta \frac{\varphi_{t+1}}{\varphi_t}\left[\int_{x_{min}}^{\bar{x}_{t+1}} N_{t+1}^p(x_{t+1})\, dF(x_{t+1}) + (1-F(\bar{x}_{t+1}))\, U_{t+1}\right]. \quad (4.14) \end{aligned}$$

Like the private sector workers, the workers in the government receive after-tax wage, suffer the disutility of working, and obtain the continuation value, which is the value of being employed if the match is not destroyed, or the value of being unemployed if the match dissolves. Thus, the value of being employed in the government sector in period t is

$$N_t^g = (1-\tau_n)\, w_t^g h_t^g + \beta \frac{\varphi_{t+1}}{\varphi_t}\left[(1-\lambda^g)\, N_{t+1}^g + \lambda^g U_{t+1}\right]. \quad (4.15)$$

Private Sector Firms

Private sector firms employ private physical capital, the household's labor, and the available technology to produce output according to a constant returns to scale production function. Private physical capital is a choice variable for the firm, but hours worked is negotiated through Nash bargaining. The production function of private firm is $y_t^p = a_t^p f\left(k_t^p, h_t^p\right)$, where a_t^p is the total factor productivity (TFP), y_t^p, k_t^p, h_t^p are output, private capital, and hours per private worker, respectively. Aggregate output and total private physical capital are related to y_t^p and k_t^p as follows

$$Y_t = n_t^p y_t^p \quad \text{and} \quad K_t^p = n_t^p k_t^p. \quad (4.16)$$

Let V_t and $J_t(x_t)$ indicate the value of a vacant job and the value of an operating job, respectively. As firms in the private sector post vacancies in the labor market at a flow cost of ι^p, which should be multiplied by z_t such that the private vacancy posting cost does not disappear in the long run. If the firm is matched and the idiosyncratic cost is low enough, the firm gains the value of being filled in the next period, otherwise it would get the value of a vacant job. The value of a vacancy is

$$V_t = -\iota^p z_t + \beta \frac{\varphi_{t+1}}{\varphi_t} \left[q_t \int_{x_{min}}^{\bar{x}_{t+1}} J_{t+1}(x_{t+1}) \, dF(x_{t+1}) + (1 - q_t F(\bar{x}_{t+1})) V_{t+1} \right]. \tag{4.17}$$

In equilibrium, any profit of new jobs is exhausted, the free entry condition implies that $V_t = V_{t+1} = 0$, thus the values of a vacancy is

$$0 = -\iota^p z_t + \beta \frac{\varphi_{t+1}}{\varphi_t} q_t \int_{x_{min}}^{\bar{x}_{t+1}} J_{t+1}(x_{t+1}) \, dF(x_{t+1}). \tag{4.18}$$

If the private firm is matched with a worker, it implements optimal production schedule to maximize profits. In addition, it also pays wages, the private physical capital cost, and the intermediate input cost. When the idiosyncratic input cost x_{t+1} is below the threshold in the next period, the match survives, otherwise it is destroyed and becomes a vacancy. Hence, the value of an operating firm is

$$J_t(x_t) = \max_{k_t^p} \left\{ y_t^p - w_t^p(x_t) h_t^p - r_t^p k_t^p - x_t z_t + \beta \frac{\varphi_{t+1}}{\varphi_t} \int_{x_{min}}^{\bar{x}_{t+1}} J_{t+1}(x_{t+1}) \, dF(x_{t+1}) \right\}. \tag{4.19}$$

The private firm choose k_t^p to maximize the present discounted value of being filled, the FOC is

$$a_t^p f_{k_t^p}\left(k_t^p, h_t^p\right) = r_t^p. \tag{4.20}$$

equation (4.20) implies that the marginal product of private physical capital should be equal to its rental rate at the optimal.

The total profit of the private firm is defined as

$$\Pi_t = n_t^p a_t^p f\left(k_t^p, h_t^p\right) - W_t^p - r_t^p n_t^p k_t^p - x_t^T z_t - \iota^p z_t v_t^p. \tag{4.21}$$

where x_t^T is the total intermediate input cost paid by the firms, i.e., $x_t^T = \frac{n_t^p}{F(\bar{x}_t)} \int_{x_{min}}^{\bar{x}_t} x_t dF(x_t)$. The total wage paid to the private sector workers W_t^p is defined as

$$W_t^p = \frac{n_t^p h_t^p}{F(\bar{x}_t)} \int_{x_{min}}^{\bar{x}_t} w_t^p(x_t) dF(x_t). \tag{4.22}$$

which indicates the average wage, conditional on working, multiplies the number of workers in the private sector firms.

Surplus, Bargaining, Wages, Hours, and Destruction Threshold

When a match becomes productive, it creates a surplus $S_t(x_t)$ which is shared between the private firm and the worker. The surplus S_t is the sum of the values of an employed worker $N_t^p(x_t)$ and an operating job $J_t(x_t)$ minus their outside options, i.e., the value of being unemployed U_t and the value of a vacant job V_t, respectively. Because of free entry, $V_t = 0$ in equilibrium. The joint surplus is $S_t(x_t) = N_t^p(x_t) + J_t(x_t) - U_t$.

Wages and hours worked in the private sector are determined through Nash bargaining between the workers and firms in the private sector. In period t, private sector wage is negotiated to maximize the Nash product

$$\max_{w_t^p(x_t)} \left(N_t^p(x_t) - U_t\right)^{\xi} \left(J_t(x_t) - V_t\right)^{1-\xi}. \tag{4.23}$$

where $\xi \in (0,1)$ is the worker's bargaining power.

The Nash bargaining problem implies that both private firms and workers receive a constant fraction of the surplus. The optimal sharing rules are:

$$N_t^p(x_t) - U_t = \frac{\xi(1-\tau_n)}{1-\xi\tau_n} S_t(x_t) \text{ and } J_t(x_t) = \frac{1-\xi}{1-\xi\tau_n} S_t(x_t). \tag{4.24}$$

Combing the optimal sharing rule (4.24) with the value equations (4.13), (4.14), (4.15), and (4.19), the surplus $S_t(x_t)$ can be expressed as

$$\begin{aligned} S_t(x_t) &= y_t^p - \tau_n w_t^p(x_t) h_t^p - r_t^p k_t^p - x_t z_t - s_t z_t + \beta \frac{\varphi_{t+1}}{\varphi_t} \\ &\quad \left(1 - p_t^p \xi \frac{1-\tau_n}{1-\xi\tau_n}\right) \int_{x_{min}}^{\bar{x}_{t+1}} S_{t+1}(x_{t+1}) \, dF(x_{t+1}) \\ &\quad -\beta \frac{\varphi_{t+1}}{\varphi_t} p_t^g \left(N_{t+1}^g - U_{t+1}\right). \end{aligned} \tag{4.25}$$

The division of of the surplus between the private sector firms and workers yields the wages paid to private employees and hours worked

$$\begin{aligned} w_t^p(x_t) h_t^p &= \xi \left[y_t^p - r_t^p k_t^p - x_t z_t + \frac{p_t^p}{q_t} \iota^p z_t \right] \\ &\quad + (1-\xi) \frac{1}{1-\tau_n} \left[s_t z_t + + \beta \frac{\varphi_{t+1}}{\varphi_t} p_t^g \left(N_{t+1}^g - U_{t+1}\right) \right]. \end{aligned} \tag{4.26}$$

where equation (4.26) is similar to the wage equation in Pissarides (2000). Private sector workers are compensated for a proportion ξ of the firm's production, and a measure of the saved vacancy posting cost. In addition, they are also compensated for the unemployment benefits, disutility of working, as well as the potential gains from working in the government sector, adjusted by labor income taxes. The hours worked in the private sector is exogenously determined.

In the private sector, if the idiosyncratic intermediate input cost to the firm is so high that it drives the joint surplus to zero, a match is endogenously dissolved by the firm and the worker. The threshold intermediate input cost $\bar{x}_t$ that destroys the match is

$$\bar{x}_t z_t = y_t^p - \tau_n w_t^p(\bar{x}_t) h_t^p - r_t^p k_t^p - s_t z_t + \beta \frac{\varphi_{t+1}}{\varphi_t}$$

$$\left(1 - p_t^p \xi \frac{1-\tau_n}{1-\xi\tau_n}\right) \int_{x_{min}}^{\bar{x}_{t+1}} S_{t+1}(x_{t+1})\, dF(x_{t+1})$$
$$-\beta \frac{\varphi_{t+1}}{\varphi_t} p_t^g \left(N_{t+1}^g - U_{t+1}\right). \tag{4.27}$$

Government

In addition to collect and spend taxes, the government sector also produces government good c_t^g employing public physical capital K_t^g, which is affected by government investment, and total hours worked in the public sector $n_t^g h_t^g$, which is influenced by government wage expenditure.

As in Cortuk and Güler (2013) and Gomes (2014), government output is not sold and hence it is not a component of aggregate output. This government good is different from private goods: it is non-rival, non-excludable, and is supplied to the household for free[6]. The character of the government product c_t^g is twofold: first, it is rationed to form effective consumption c_t together with private consumption c_t^p; second, it is used to pay the recruitment cost in the government sector. The government production function is specified as

$$c_t^g = a_t^g \left(K_t^g\right)^\gamma \left(n_t^g h_t^g\right)^{1-\gamma} - \iota^g v_t^g. \tag{4.28}$$

where $\gamma \in (0,1)$ measures the elasticity of government output with respect to public physical capital. a_t^g is the aggregate productivity measure in the government sector. ι^g is the vacancy posting cost in the public sector, and v_t^g is the number of vacancies posted by the government at period t. Government capital K_t^g is accumulated through government investment I_t^g, and evolves as

$$K_{t+1}^g = (1-\delta^g) K_t^g + I_t^g. \tag{4.29}$$

[6]This specification of government production and assumption of government good is pioneered by Gomes (2011), Cortuk and Güler (2013) adopt a similar specification and assumption. Government good is not a component of total output is because is is not sold in the market, as argued by Cortuk and Güler (2013).

The government imposes consumption tax τ_c, labor tax τ_n, capital tax τ_k, and a lump sum tax T_t to finance its aggregate expenditure, which is a fraction χ_t of aggregate output Y_t. Thus,

$$\chi_t Y_t = \tau_c c_t^p + \tau_n \left(W_t^p + W_t^g\right) + \tau_k \left(r_t^p - \delta^p\right) K_t^p + T_t + D_t. \tag{4.30}$$

where D_t is the flow of government deficit, which accumulated as government debt, and $W_t^g = w_t^g n_t^g h_t^g$. The government revenue are spent on compensation of government employees $w_t^g n_t^g h_t^g$, government investment I_t^g, and consumption expenditure g_t^g, hence the aggregate government spending can be explicitly expressed as

$$\chi_t Y_t = w_t^g n_t^g h_t^g + I_t^g + g_t^g - u_t s_t z_t. \tag{4.31}$$

Blanchflower (1996) shows that he estimated average public sector wages were 1.34% to 13.34% higher than private sector wages. Gregory and Borland (1999) documents more facts of public wage premium. According to these empirical evidence, and following Gomes (2014) and Michaillat (2011), the government wage is specified as

$$w_t^g = (1 + \pi^g) w_t^p. \tag{4.32}$$

where π^g is a parameter measuring the net premium of government sector wage.

Perfect Foresight Competitive Equilibrium

To close the model, we characterize the equilibrium that we are interested in. The definition of perfect foresight competitive equilibrium below summarizes the overall framework of our model.

Definition 1. Given the path of TFP $\left\{a_t^p, a_t^g, h_t^p\right\}_{t=0}^{\infty}$, the sequence of government taxes, spending shares, public vacancies, hours worked, and unemployment insurances $\left\{\tau_c, \tau_n, \tau_k, D_t, \chi_t, v_t^g, h_t^g\right\}_{t=0}^{\infty}$, $\left\{GWE_t, I_t^g, g_t^g, s_t\right\}_{t=0}^{\infty}$, and initial capital stock K_0, a perfect foresight competitive equilibrium is a set of prices $\{w_t^p(x_t), r_t^p, w_t^g\}_{t=0}^{\infty}$, a sequence of quantities $\{c_t^p, K_{t+1}^p, k_t^p, n_t^p, n_t^g, u_t, v_t^p, \theta_t, \bar{x}_t, Y_t, y_t^p, c_t^g\}_{t=0}^{\infty}$, $\{K_t^g, m_t^p, m_t^g, p_t^p\}_{t=0}^{\infty}$, and $\{p_t^g, S_t, \varphi_t, T_t\}_{t=0}^{\infty}$ satisfy:

(a) Agents optimize:

$(a.1)$ The household's maximization conditions (4.11) and (4.12) are satisfied;

$(a.2)$ The value functions in the labor market (4.13), (4.14), (4.15), (4.18), (4.19) are met;

$(a.3)$ The private sector physical capital demand should satisfy (4.20);

$(a.4)$ The private wage (4.26) solves the Nash bargaining;

$(a.5)$ The destruction threshold satisfy the zero surplus condition (4.27);

(b) Markets clear:

$(b.1)$ The consumption goods market satisfy $Y_t = c_t^p + K_{t+1}^p - (1-\delta^p)K_t^p + v_t^p \iota^p z_t + n_t^p x_t z_t - u_t s_t z_t + w_t^g n_t^g h_t^g + I_t^g + g_t^g$;

$(b.2)$ The market for private capital satisfies (4.16);

$(b.3)$ The market for labor meets (4.4), (4.5), and (4.1);

(c) Government behavior:

$(c.1)$ The government budget should satisfy (4.30) and (4.31);

$(c.2)$ The government sector wage should meet (4.32);

$(c.3)$ The government production should follow (4.28);

(d) The evolution of the whole system is governed by the law of motions for labor (4.4), (4.5), and (4.1); as well as the law of motion for government physical capital (4.29).

To numerically solve the model, we rewrite the equilibrium conditions in terms of stationary variables, which are obtained through dividing each of the non-stationary variables by z_t. On the balanced growth path, z_t grows at the average growth rate of TFP factor, $\left(a_t^p\right)^{\frac{1}{1-\alpha}}$, which is $\frac{\bar{\kappa}}{1-\alpha}$[7]. The steady state of the economy is a perfect foresight competitive equilibrium in which all stationary variables are constant. The characterization of this perfect foresight competitive equilibrium is in Appendix 4.F.

[7]Here $\bar{\kappa}$ is the average growth rate of TFP, a_t^p, along the balanced growth path.

4.5 Calibration

We now describe the method employed to parameterize the model, and explain the simulation techniques, as well as the assumptions associated with the exogenous variables of our model.

Calibration

We choose functional forms which are conventional in the literature and then calibrate the model to match the stylized facts of Japan in 1990, which is specified as the initial steady state in our simulation. The length of period is to one quarter.

The utility function is assumed to be additively separable in consumption and individual labor supply, the relative risk aversion is set at $\sigma = 1.00$, such that the utility function on consumption is in logarithms. As in the literature (e.g., Esteban-Pretel et al., 2010), the quarterly discount factor is set at $\beta = 0.9957$.

In our benchmark simulation, the share of private consumption is set at $\phi = 0.70$ as in Bruckner and Pappa (2012). According to the study by García and Llopis (2005), the consumption substitutability ζ is set at $\zeta = 2.00$.

According to Mendoza et al. (1994) and Esteban-Pretel et al. (2010), the proportional labor tax τ_n and the proportional capital tax τ_k are relatively stable during the 1990s. These two tax rates are set at $\tau_n = 0.28$ and $\tau_k = 0.44$, which are the average from 1990 to 1996 from the extended dataset of Mendoza et al. (1994). The consumption tax τ_c is set at $\tau_c = 0.03$, which is the average level from 1990 to 1997[8].

The production function of the private sector firm is $y_t^p = a_t^p \left(k_t^p\right)^{\alpha} \left(h_t^p\right)^{1-\alpha}$, which is the standard Cobb-Douglas function. Employing the extended data in Braun et al.

[8] The consumption tax rate was increased from 0.03 to 0.05 in 1997, we choose $\tau_c = 0.03$ as the value used in our benchmark calibration, our results are also robust to alternative values of consumption tax, such as $\tau_c = 0.05$.

(2006a), we estimate the share of capital revenue in output α and the depreciation rate in private sector δ^p, which are set at $\alpha = 0.383$ and $\delta^p = 0.028$, respectively. We assume that the depreciation rate of physical capital in the public sector is the same as that in the private sector, thus, $\delta^g = 0.028$. The initial private sector technology a^p_{1990Q1} and initial government sector technology a^g_{1990Q1} are normalized to unity. The long run growth rate of TFP, $\bar{\kappa}$, is assumed to be 0.94%, which is the average in the data from 1990 to 2002.

In the labor market, the elasticity of matching m_t with respect to unemployment u_t, μ is set at $\mu = 0.5$, which is standard in this type of literature. According to the Hosios (1990) condition, we pin down the bargaining power of the worker ξ as $\xi = 0.50$. The public vacancy posting cost ι^g is a free parameter, it is calculated such that the public vacancy posting cost is about half of the private vacancy posting cost as in Gomes (2011), thus $\iota^g = 0.0523$.

The intermediate idiosyncratic cost is assumed to follow an exponential distribution, $x \sim \frac{1}{\chi} e^{-\frac{x}{\chi}}$, where $x_{min} = 0$, $x_{max} = +\infty$, and we only need to calibrate the mean of the exponential distribution, χ. χ is jointly calibrated with the matching efficiency parameter η, the private vacancy posting cost ι^p, the number of public vacancy v^g to match the unemployment rate, the job finding probabilities, the share of people working in the government sector in 1990, respectively, as well as the labor market tightness of unity. The endogenously calibrated parameter values are $\chi = 0.2075$, $\eta = 0.4116$, $\iota^p = 0.1614$, and $v^g = 0.0006$, respectively.

According to the empirical study of Esteban-Pretel et al. (2011b), we set the quarterly probability of job destruction in the government sector, λ^g, as $\lambda^g = 0.0039$. Based on a comparative study about wages in the government sector and private sector in Japan by Morikawa (2014), we set the public wage premium π^g at $\pi^g = 0.10$[9]. The share of public physical capital in government production γ is set to be $\gamma = 0.10$ according to the

[9]In Table 3 of Morikawa (2014), the estimated public sector wage premium for both male and female varies from 29.5% at the lower side of the wage distribution to 0.67% at higher end of the wage distribution, alternative values of public sector wage premiums were employed for robustness purposes, our results are robust to different values of π^g.

estimate in Cubas (2011). Based on the study by Iwaisako (2014), the steady state D is set at $D = 0.02$, which is around the ratio of government budget balance to GDP in 1990.

Simulation Technique and Path of Exogenous Variables

We simulate the above constructed model by postulating that the economy transitions from its initial steady state in 1990, to a final steady state at a point far enough away in the future[10]. The length of time in simulating the model is one quarter, but the data is aggregated later at annual frequency, as we are interested in the long-term transition of the economy rather than its short-run fluctuations. The simulation is deterministic, and the perfect foresight agents know the paths of exogenous variables which evolve exogenously over time.

The data on TFP growth rate and hours per worker in the government sector is an extended version of Braun et al. (2006b). The paths of these exogenous variables in the data are as follows.

The growth rate of TFP, κ_t: The path of technology growth rate, κ_t, is calculated from the data as the period to period change, i.e., $e^{\kappa_t} = \frac{a_t^p}{a_{t-1}^p}$, from 1990 to 2002, and it remains constant at the average growth rate along the balanced growth path after 2002, $\bar{\kappa}$.

The private hours of work, h_t^p: We employ the time series of hours of work from Esteban-Pretel et al. (2010), which demonstrates that it decreases from the initial level of 44 to the final value of 38 under the sample period, and remains constant after the last period.

The share of government wage expenditure, GWE_t: We constructed this time series from the system of national accounts table and OECD dataset[11], it is defined as the ratio

[10]The model is simulated using the equations exhibited in Appendix 4.F, the calibrated parameters in our previous subsection, as well as the paths of exogenous variables that we explained in this subsection. The simulations were performed using the Dynare package with MATLAB, version 4.4.3.

[11]We employ the share of government wage expenditure in the OECD data of the Japanese economy to disaggregate the raw government consumption expenditure from the system of national accounts table into two components: the government consumption expenditure and government consumption expenditure. We really appreciate Bermperoglou Dimitrios, Pappa Evi, and Vella Eugenia for sharing the disaggregated time series of Japanese government expenditures with us, and they obtain these disaggregated time series of different government expenditures from OECD Economic Outlook N.90, whose official webpage is

of government wage to GDP. From 1990 to 2002, the share of government wage slightly increases from 0.0618 to 0.0665. It is assumed to be constant after the last period in our sample.

The share of government investment expenditure, I_t^g: We constructed this time series from the system of national accounts table, it is defined as the ratio of government investment to GDP. From 1990 to 2002, the share of government investment slightly decreases from 0.0635 to 0.0632. We assume that it remains constant after the last period in our sample.

The share of government consumption expenditure, g_t^g: We constructed this time series by combining the system of national accounts table and OECD dataset, it is defined as the ratio of the computed government consumption expenditure to GDP. The share of government consumption expenditure increases from 0.7706 to 0.1109. It remains constant at the final level after the last period.

4.6 Simulation Results

The results of our benchmark simulation are reported in Figure 4.2 and Figure 4.3. These two figures demonstrate that our model is successful in replicating the transitional path of the main labor market variables observed in the data from 1990 to 2002.

Figure 4.2 shows that the unemployment rate increases from 2.08% in 1990 to 5.40% in 2002, which is attributable to the decline in TFP growth, the decrease in hours worked in the private sector, the decrease in government investment spending, and no contractionary tax policy. Our model can successfully reproduce the actual path of the unemployment rate over the 1990s.

The decrease in the growth rate of TFP leads to a drop in the detrended TFP level, while firms in the private sector could not ask their employees to work longer because of

http://www.oecd-ilibrary.org/economics/data/oecd-economic-outlook-statistics-and-projections_eo-data-e.

the exogenous decrease in hours reduces private firm's profits. Hence, the productive private firms have more incentive to cease the ongoing matches, which increases the probability of losing jobs, as shown in Figure 4.3b. Meanwhile, the potential entrants would expect lower profits, and thus less vacancies would be posted, which plus the increased unemployment reduces the probability of finding jobs, as shown in Figure 4.3a. Our model is capable of reproducing the dynamic movements of these two variables during the lost decade.

In addition, our model is also able to reproduce the dynamic movements of the fraction of workers who lose jobs and those who find jobs in the 1990s, as shown in Figure 4.3c and Figure 4.3d. On the one hand, the number of workers losing jobs is higher than the number of workers finding jobs at each period. On the other hand, government investment spending slightly decreases from 6.35% to 6.32% and there is no contractionary tax, so the stimulating effects of expansionary fiscal policies are absent from our benchmark simulation. Therefore, our model reproduces an increase in the unemployment rate from 1990 to 2002.

4.7 The Effects of Fiscal Policy Changes

In this section, we investigate the impact of fiscal policy changes, i.e., changes in government spending and changes in taxes, on the unemployment in 2002, which is the end of the Lost Decade, through conducting counterfactual experiments employing our calibrated model.

We first consider the fiscal policy changes from the spending side, and examine what would be the unemployment rate in 2002 if the government did not change the share of government wage, government consumption, and government investment spending, respectively, during the Lost Decade. This counterfactual experiment is implemented by fixing the share of government wage, government consumption, and government investment spending during the Lost Decade at their 1990Q1 level, respectively.

Then we investigate the impact of fiscal policy changes from the tax perspective, and examine what would be the unemployment rate in 2002 if the government adopted contractionary tax policies during the Lost Decade. This counterfactual experiment is implemented by reducing the labor tax, capital tax, or consumption tax by 10% after 1990 and keep the new tax rate constant during the lost decade, respectively.

Figure 4.4 and Table 4.5 report our simulation results from counterfactual experiment I. We observe three interesting findings. First, if government did not increase government consumption expenditure, i.e., the share of government consumption is fixed at the 1990's level, the unemployment rate in 2002 would be 5.90% higher than the benchmark simulation, this result is intuitive since increasing government spending stimulates output and reduces unemployment rate during the lost decade. Second, if government did not reduce government wage, i.e., the share of government wage is fixed at the 1990's level, the unemployment rate in 2002 would be 0.37% lower than our benchmark simulation. Third, if government didn't decrease government investment, that is, if the share of government investment is fixed at the 1990's level, the unemployment rate at the end of the Lost decade would be 7.56% lower. These counterfactual results are consistent with the intuition that government spending expansion reduces unemployment rate while government spending contraction increases unemployment rate. The policy implication is that during the Lost Decade, if government wants to reduce the unemployment rate, increasing government spending is the one candidate policy instrument.

Figure 4.5 and Table 4.5 summarize our simulation results from counterfactual experiment II. Three salient characteristics are revealed: First, if the proportional labor income tax was reduced by 10% after 1990 and stayed at that level, i.e., 0.2520, the unemployment rate at the end of the Lost Decade would reduce by 15.87%, meanwhile, the unemployment rates during the Lost Decade also decreased. The reason is that reducing proportional labor tax increases the value of working and hence the surplus of an operating match, which encourages vacancy posting and hiring, thus output increases and unemployment decreases. Second, if the proportional capital income tax was reduced by 10% after 1990 and stayed at that level, i.e., 0.3960, the unemployment rate at 2002 would decrease by 9.59%, at the same time, the unemployment rates in the 1990s also declined. The intuition is that if proportional capital tax is reduced, firms have higher incentive to invest in physical capital, leading to increases in the future capital stock and the marginal product of labor, which encourages hiring and reduces unemployment. Third, if the proportional consumption income tax was reduced by 10% after 1990 and stayed at that level, i.e., 0.0270, the unemployment rate at the end of the Lost Decade would decrease by 13.83%, moreover, the unemployment rates during the Lost Decade also reduced. The intuition is that reducing proportional consumption tax increases the value of working, leading to increases in the surplus, which encourages vacancy posting and hiring, thus output increases and unemployment decreases.

These counterfactual experiments demonstrate that during the 1990s, changes in different government spending components affect the unemployment rate heterogeneously, increases in government consumption expenditure and government wage prevented the unemployment rate during the Lost Decade to rise to a much higher level, but the decreases in government investment expenditure contributed to the surge of the unemployment rate in the 1990s. In addition, the unemployment rates in the 1990s would have been lower than the actual ones if the Japanese government adopted the contractionary tax policy.

4.8 Conclusion

The unemployment rate in Japan increases from 2.08% in 1990 to 5.40% in 2002, during the same period, the job finding probability decreased and the job losing probability increased. Meanwhile, the Japanese economy experienced changes in fiscal policies both from the spending aspect and the revenue aspect.

We build, calibrate, and simulate a neo-classical growth model with search and matching frictions, a productive government sector, and different categories of taxes to evaluate the impacts of changes in fiscal policies on labor market variables in the 1990s of Japan. The paths of TFP, private hours worked, government wage, government consumption, and government investment are fed into our deterministic simulation to evaluate the performance of our model.

We find that if government investment and wage didn't decrease, the unemployment rate in 2002 would be 7.56% and 0.36% lower, respectively, while it would be 5.90% higher if government consumption did not increase. The reason is that the wealth effect increases the value of being employed and decreases the value of being unemployed, leading to rising matching surplus, which encourages hiring and reduces unemployment. Meanwhile, 10% tax reductions in labor, capital, and consumption after 1990 would reduce the unemployment rate in 2002 by 15.87%, 9.59%, and 13.83% respectively. The intuition is that different categories of taxes affect the economy heterogeneously: labor tax directly influences the value of employed workers, capital tax affects the accumulation of capital and hence the value of vacancy posting, while consumption tax affects the wealth of the household.

Our study demonstrates that both increasing government spending and reducing taxes could be employed as policy instruments to cushion the labor market during the Lost Decade, and countercyclical government fiscal policies contribute to reduce the unemployment rate during the 1990s in Japan.

4.A Main Tables

Table 4.1: Parameter Values: Exogenously Assigned

Parameter	Notation	Value	Source
Private depreciation rate	δ^p	0.0285	Braun et al. (2006a)
Capital revenue in output	α	0.3830	Braun et al. (2006a)
Private consumption share	ϕ	0.7000	Bruckner and Pappa (2012)
Consumption substitutability	ζ	2.0000	García and Llopis (2005)
Relative risk aversion	σ	1.0000	Esteban-Pretel et al. (2010)
Matching elasticity	μ	0.5000	Esteban-Pretel et al. (2010)
Public job destruction	λ^g	0.0039	Esteban-Pretel et al. (2011a)
Public wage premium	π^g	0.1000	Morikawa (2014)
Private capital share	γ	0.1000	Cubas (2011)
Balanced deficit GDP ratio	D	0.0200	Iwaisako (2014)
Public depreciation rate	δ^g	0.0285	$\delta^g = \delta^p$
Worker's bargaining power	ξ	0.5000	$\xi = \mu$
Public vacancy cost	ι^g	0.0523	Exogenously set
Discount factor	β	0.9957	Data moment
Labor tax	τ_n	0.2800	Data moment
Capital tax	τ_k	0.4400	Data moment
Cconsumption tax	τ_c	0.0300	Data moment
Long run growth rate of TFP	$\bar{\kappa}$	0.0094	Data moment
Value of home production	x^b	0.1000	Exogenously set

Table 4.2: Parameter Values: Endogenously Calibrated

Parameters	Notation	Value	Target
Public vacancy	v^g	0.0006	Share of public workers
Matching efficiency	η	0.4116	Labor market tightness
Private vacancy cost	ι^p	0.1614	Unemployment rate
Mean of exponetial distribution	χ	0.2075	Job finding probability

Table 4.3: The Unemployment Rate: Benchmark and Experiment I

Year	Benchmark	Fixing GWE	Fixing GCE	Fixing GIE
1990	1.99	1.99	1.99	2.00
1991	2.02	2.03	2.05	2.05
1992	2.24	2.25	2.29	2.29
1993	2.56	2.57	2.65	2.61
1994	2.90	2.91	3.02	2.93
1995	3.11	3.12	3.26	3.11
1996	3.04	3.05	3.20	3.00
1997	3.23	3.24	3.42	3.14
1998	3.80	3.81	4.04	3.66
1999	4.23	4.24	4.52	4.03
2000	4.45	4.45	4.76	4.18
2001	4.88	4.88	5.21	4.55
2002	5.42	5.40	5.74	5.01

Notes: (1) The values of unemployment rate reported in this table are in percentage point; (2) In title, fixing GWE, GCE, GIE means the share of each was kept at the 1990Q1 level, respectively.

Table 4.4: The Unemployment Rate: Benchmark and Experiment II

Year	Benchmark	Labor Tax	Capital Tax	Consumption Tax
1990	1.99	1.84	1.99	1.99
1991	2.02	1.69	2.00	1.99
1992	2.24	1.86	2.18	2.15
1993	2.56	2.12	2.46	2.41
1994	2.90	2.41	2.76	2.68
1995	3.11	2.59	2.93	2.84
1996	3.04	2.52	2.84	2.73
1997	3.23	2.68	2.99	2.87
1998	3.80	3.17	3.50	3.35
1999	4.23	3.54	3.88	3.70
2000	4.45	3.73	4.06	3.87
2001	4.88	4.10	4.44	4.22
2002	5.42	4.56	4.90	4.67

Notes: (1) The values of unemployment rate reported in this table are in percentage point; (2) Labor, capital, and consumption tax means each tax was reduced by 10%*, respectively.*

Table 4.5: Percentage Changes of The Unemployment Rate in 2002

	Poliocy 1	Poliocy 2	Poliocy 3
Policy	Fixing GWE	Fixing GCE	Fixing GIE
Change	-0.3690	5.9041	-7.5646
Policy	Labor Tax	Capital Tax	Consumption Tax
Change	-15.87	-9.59	-13.83

Notes: (1) The values of changes reported in this table are in percentage point; (2) These changes are calculated by comparing the benchmark simulation results and the counterfactuals.

4.B Main Figures

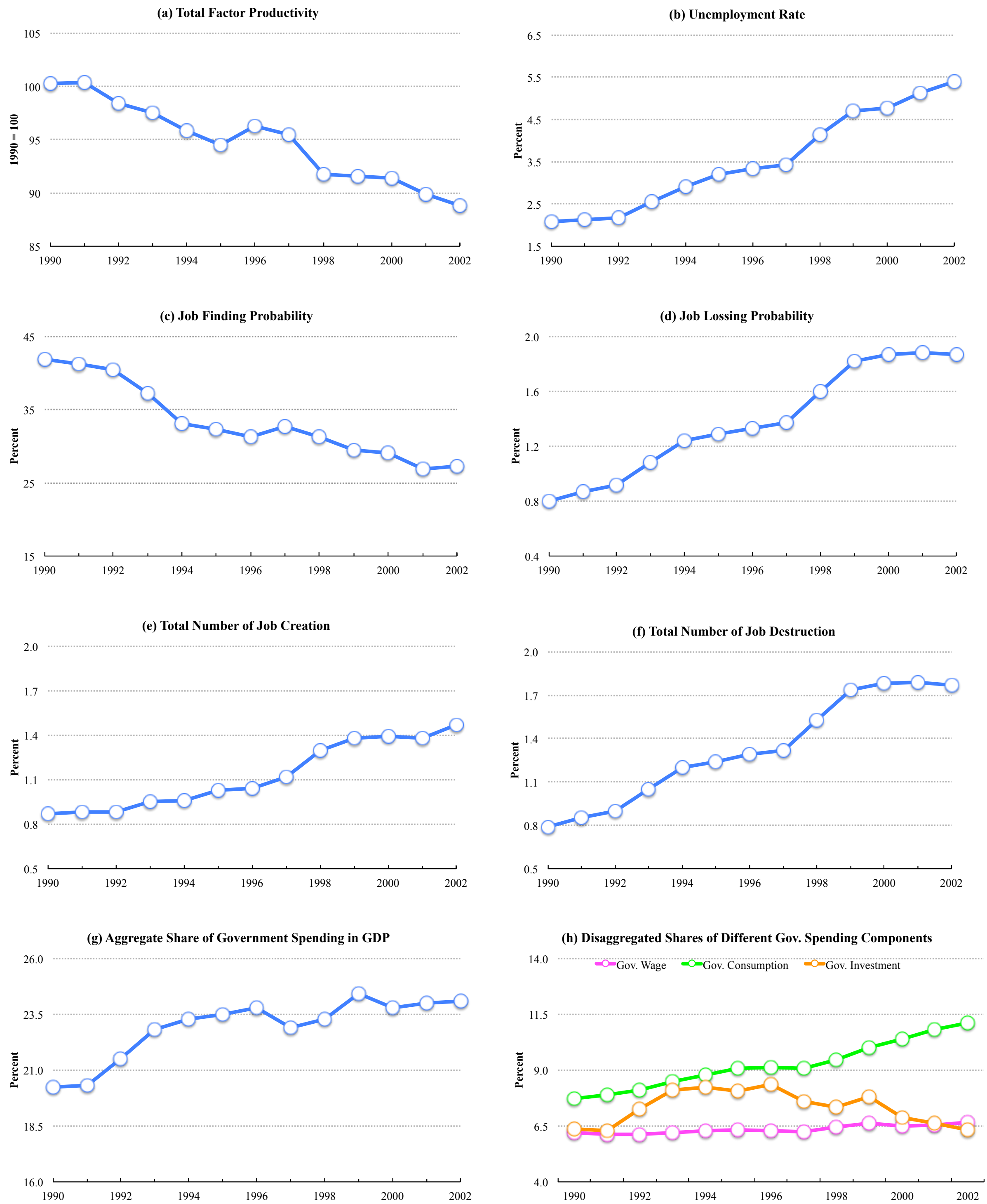


Figure 4.1: The Stylized Facts of Japanese Labor Market During the 1990s

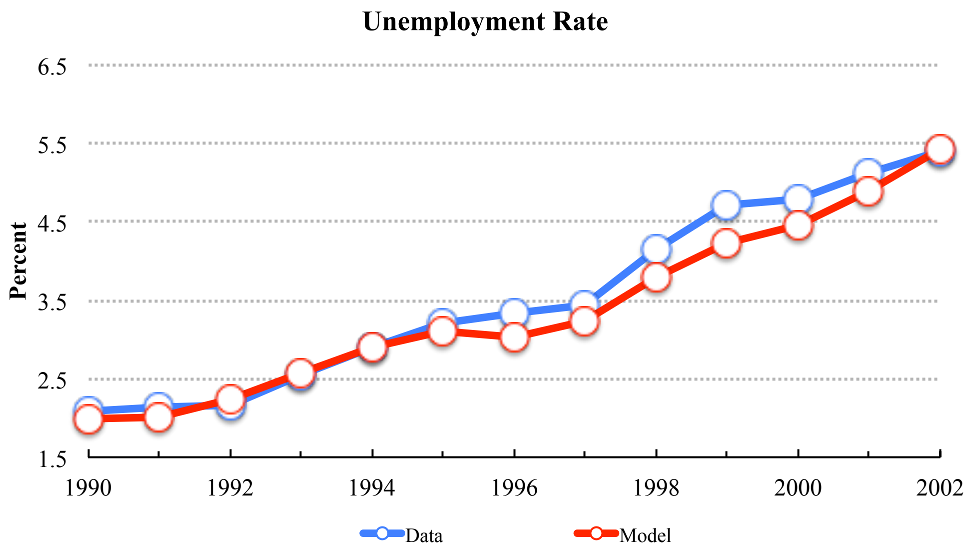


Figure 4.2: The Data and Simulation's Unemployment Rate

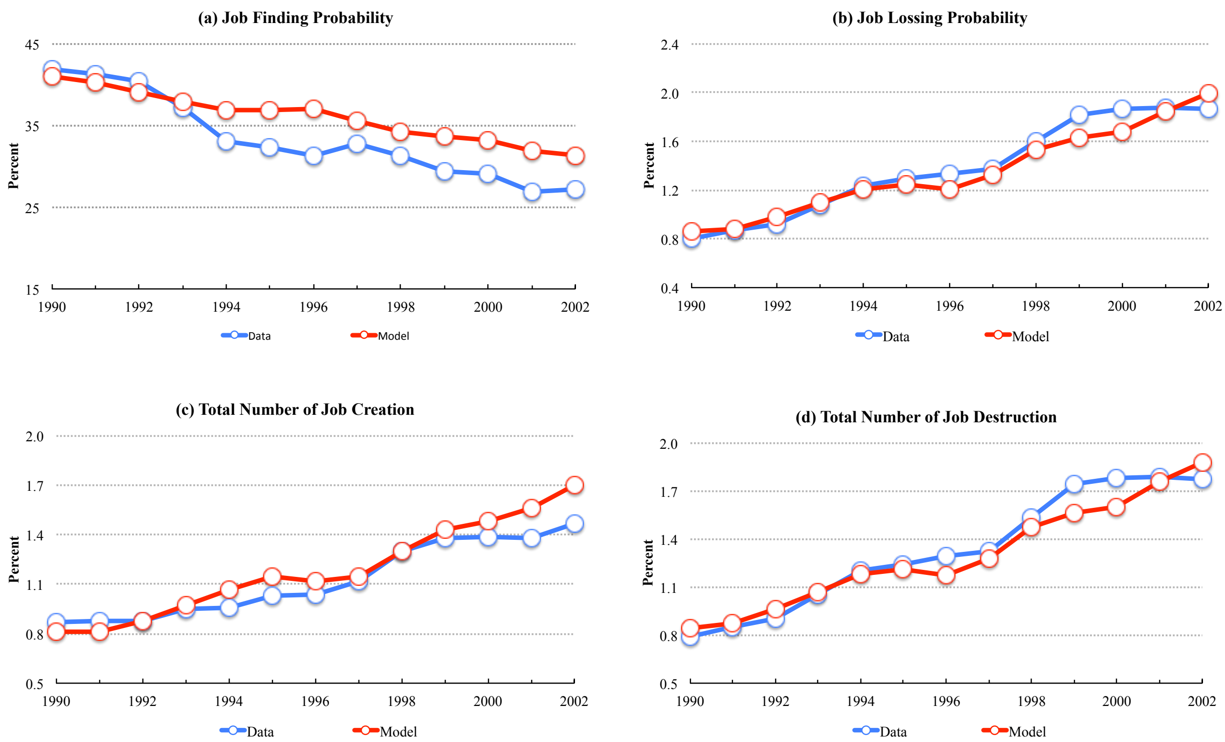


Figure 4.3: The Data and Simulation's Flows In and Out of Unemployment

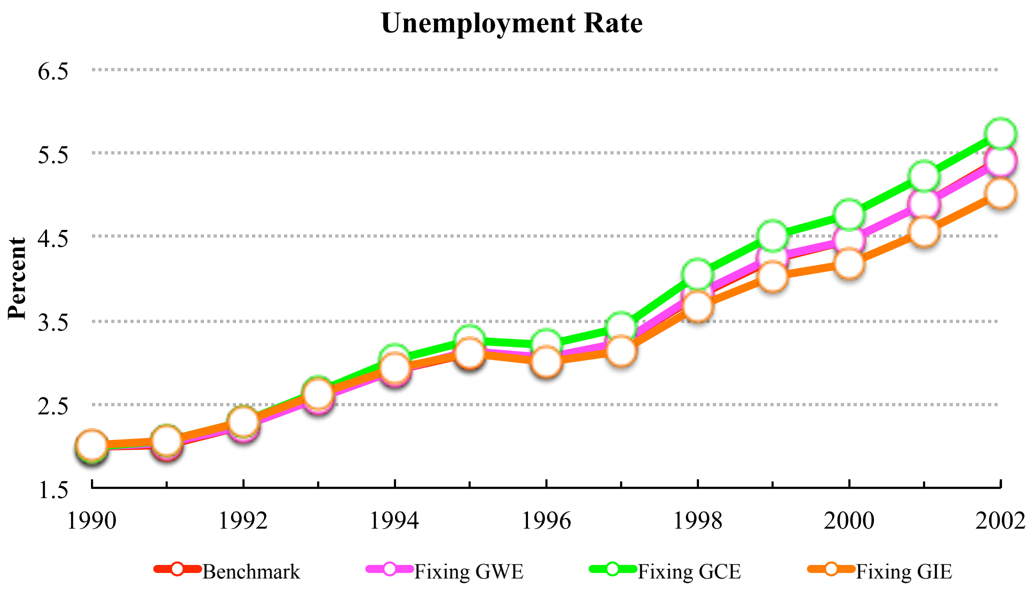


Figure 4.4: The Benchmark and Counterfactual's Unemployment Rate: Experiment I

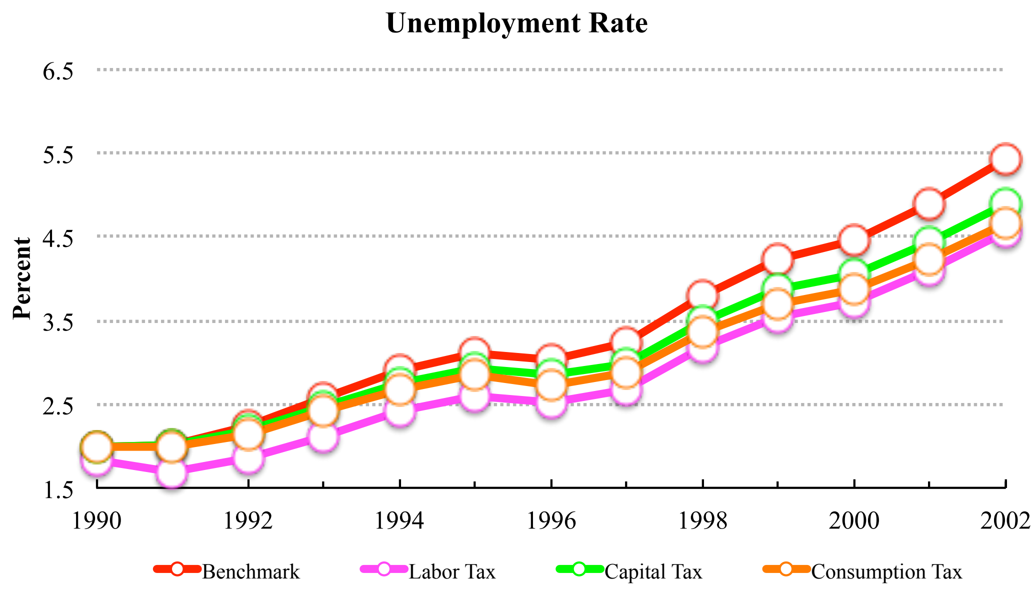


Figure 4.5: The Benchmark and Counterfactual's Unemployment Rate: Experiment II

4.C Data Source and Description

Sources of Data

The data employed in our study comes from five sources: (I) System of National Accounts (SNA), Cabinet Office, Japan; (II) Labor Force Survey (LFS), Statistics Bureau, Ministry of Internal Affairs and Communications, Japan; (III) Excel Files for Hayashi and Prescott, "The 1990s in Japan: A Lost Decade"; (IV) The data file to accompany the published paper Esteban-Pretel et al. (2010) by two of the coauthors; (V) OECD Economic Outlook N.90.

Construction of Disaggregated Government Spending

We really appreciate Bermperoglou Dimitrios (Universitat Autònoma de Barcelona, UAB), Pappa Evi (European University Institute), and Vella Eugenia (European University Institute) for sharing the disaggregated time series of Japanese government expenditures with us, and they obtain these disaggregated time series of different government expenditures from OECD Economic Outlook N.90, whose official webpage is http://www.oecd-ilibrary.org/economics/data/oecd-economic-outlook-statistics-and-projections eo-data-e.

We employ the share of government wage expenditure in the OECD data of the Japanese economy to disaggregate the raw government consumption expenditure from the system of national accounts table into two components: the government consumption expenditure and government consumption expenditure.

4.D Proof of Key Equations

Proof of Equation (4.11)

Setting up the Lagrangian of the household's problem

$$\begin{aligned}\mathscr{L} &= \sum_{j=0}^{\infty}\beta^{j}\left\{\frac{\left\{\left[\phi\left(c_{t+j}^{p}\right)^{\frac{\zeta-1}{\zeta}}+(1-\phi)\left(c_{t+j}^{g}\right)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{\zeta}{\zeta-1}}\right\}^{1-\sigma}-1}{1-\sigma}\right. \\ &\quad +\varphi_{t+j}\left[(1-\tau_n)\left(W_{t+j}^{p}+W_{t+j}^{g}\right)+u_{t+j}s_{t+j}z_{t+j}+(1-\delta^{p})K_{t+j}^{p}\right. \\ &\quad +r_{t+j}^{p}K_{t+j}^{p}-\tau_k\left(r_{t+j}^{p}-\delta^{p}\right)K_{t+j}^{p}+\Pi_{t+j}-T_{t+j} \\ &\quad \left.\left.-(1+\tau_c)c_{t+j}^{p}-K_{t+1+j}^{p}\right]\right\} \qquad (4.D1)\end{aligned}$$

The first order conditions are characterized by

c_t^p: $\left[(\dot{c}_t)^{\frac{\zeta}{\zeta-1}}\right]^{-\sigma}(\dot{c}_t)^{\frac{1}{\zeta-1}}\phi\left(c_t^p\right)^{\frac{-1}{\zeta}}=\varphi_t(1+\tau_c)$

K_{t+1}^p: $\varphi_t=\beta\varphi_{t+1}\left[1+(1-\tau_k)\left(r_{t+1}^p-\delta^p\right)\right]$

where $\dot{c}_t=\phi\left(c_t^p\right)^{\frac{\zeta-1}{\zeta}}+(1-\phi)\left(c_t^g\right)^{\frac{\zeta-1}{\zeta}}$.

Proof of Equation (4.24) **and Equation** (4.25)

From the Nash product (4.23), (4.14), (4.13), (4.19), the FOC with respect to the private wage $w_t^p(x_t)$ is

$$\text{LHS} = \xi\left(N_t^p(x_t)-U_t\right)^{\xi-1}\left(J_t(x_t)-V_t\right)^{1-\xi}\frac{\partial N_t^p(x_t)}{\partial w_t^p(x_t)} \qquad (4.D2)$$

$$\text{RHS} = -(1-\xi)\left(N_t^p(x_t)-U_t\right)^{\xi}\left(J_t(x_t)-V_t\right)^{-\xi}\frac{\partial J_t(x_t)}{\partial w_t^p(x_t)} \qquad (4.D3)$$

As $\frac{\partial N_t^p(x_t)}{\partial w_t^p(x_t)}=(1-\tau_n)h_t^p$, $\frac{\partial J_t(x_t)}{\partial w_t^p(x_t)}=-h_t^p$, combining (4.D2) with (4.D3), and canceling common terms,

$$\xi\left(1-\tau_n\right)J_t\left(x_t\right) \;=\; \left(1-\xi\right)\left(N_t^p\left(x_t\right)-U_t\right) \tag{4.D4}$$

therefore, $N_t^p\left(x_t\right)-U_t=\frac{\xi\left(1-\tau_n\right)}{1-\xi\tau_n}S_t\left(x_t\right)$, and $J_t\left(x_t\right)=\frac{1-\xi}{1-\xi\tau_n}S_t\left(x_t\right)$.

Since $S_t\left(x_t\right)=N_t^p\left(x_t\right)+J_t\left(x_t\right)-U_t$, combining with (4.13), (4.14), (4.15), and (4.19) delivers

$$\begin{aligned} S_t\left(x_t\right) \;=\; & =y_t^p-\tau_n w_t^p\left(x_t\right)h_t^p-r_t^p k_t^p-x_t z_t-s_t z_t+\beta\frac{\varphi_{t+1}}{\varphi_t}\int_{x_{min}}^{\bar{x}_{t+1}}S_{t+1}\left(x_{t+1}\right)dF\left(x_{t+1}\right) \\ & -\beta\frac{\varphi_{t+1}}{\varphi_t}\left[p_t^p\int_{x_{min}}^{\bar{x}_{t+1}}\left(N_{t+1}^p\left(x_{t+1}\right)-U_{t+1}\right)dF\left(x_{t+1}\right)\right. \\ & \left.+p_t^g\left(N_{t+1}^g-U_{t+1}\right)\right] \end{aligned} \tag{4.D5}$$

Employing the optimal sharing rule and rearranging yields

$$\begin{aligned} S_t\left(x_t\right) \;=\; & y_t^p-\tau_n w_t^p\left(x_t\right)h_t^p-r_t^p k_t^p-x_t z_t-s_t z_t+\beta\frac{\varphi_{t+1}}{\varphi_t} \\ & \left(1-p_t^p\xi\frac{1-\tau_n}{1-\xi\tau_n}\right)\int_{x_{min}}^{\bar{x}_{t+1}}S_{t+1}\left(x_{t+1}\right)dF\left(x_{t+1}\right) \\ & -\beta\frac{\varphi_{t+1}}{\varphi_t}p_t^g\left(N_{t+1}^g-U_{t+1}\right) \end{aligned} \tag{4.D6}$$

Proof of Equation (4.26)

From $N_t^p\left(x_t\right)-U_t=\frac{\xi\left(1-\tau_n\right)}{1-\xi\tau_n}S_t\left(x_t\right)$, value equations (4.13), (4.14), and the surplus (4.D6), we have

$$\begin{aligned} & \left(1-\tau_n\right)w_t^p\left(x_t\right)h_t^p-s_t z_t \\ & +\beta\frac{\varphi_{t+1}}{\varphi_t}\left(1-p_t^p\right)\frac{\xi\left(1-\tau_n\right)}{1-\xi\tau_n}\int_{x_{min}}^{\bar{x}_{t+1}}S_{t+1}\left(x_{t+1}\right)dF\left(x_{t+1}\right)-\beta\frac{\varphi_{t+1}}{\varphi_t}p_t^g\left(N_{t+1}^g-U_{t+1}\right) \end{aligned}$$

$$
\begin{aligned}
= & \frac{\xi\left(1-\tau_n\right)}{1-\xi\tau_n}\left[y_t^p-\tau_n w_t^p\left(x_t\right)h_t^p-r_t^p k_t^p-x_t z_t-s_t z_t+\beta\frac{\varphi_{t+1}}{\varphi_t}\right. \\
& \left.\left(1-p_t^p\xi\frac{1-\tau_n}{1-\xi\tau_n}\right)\int_{x_{min}}^{\bar{x}_{t+1}}S_{t+1}\left(x_{t+1}\right)dF\left(x_{t+1}\right)-\beta\frac{\varphi_{t+1}}{\varphi_t}p_t^g\left(N_{t+1}^g-U_{t+1}\right)\right] \quad (4.D7)
\end{aligned}
$$

Combining terms and rearranging gives

$$
\begin{aligned}
& w_t^p\left(x_t\right)h_t^p \\
= \; & \xi\left[y_t^p-r_t^p k_t^p-x_t z_t+\beta\frac{\varphi_{t+1}}{\varphi_t}p_t^p\frac{1-\xi}{1-\xi\tau_n}\int_{x_{min}}^{\bar{x}_{t+1}}S_{t+1}\left(x_{t+1}\right)dF\left(x_{t+1}\right)\right] \\
& +\frac{1-\xi}{1-\tau_n}\left[s_t z_t+\beta\frac{\varphi_{t+1}}{\varphi_t}p_t^g\left(N_{t+1}^g-U_{t+1}\right)\right] \quad (4.D8)
\end{aligned}
$$

Employing the free entry condition and rearranging delivers

$$
\begin{aligned}
w_t^p\left(x_t\right)h_t^p = \; & \xi\left[y_t^p-r_t^p k_t^p-x_t z_t+\frac{p_t^p}{q_t}\iota^p z_t\right] \\
& +\left(1-\xi\right)\frac{1}{1-\tau_n}\left[s_t z_t+\beta\frac{\varphi_{t+1}}{\varphi_t}p_t^g\left(N_{t+1}^g-U_{t+1}\right)\right] \quad (4.D9)
\end{aligned}
$$

The FOC with respect to private hours worked h_t^p is

$$
\text{LHS} = \xi\left(N_t^p\left(x_t\right)-U_t\right)^{\xi-1}\left(J_t\left(x_t\right)-V_t\right)^{1-\xi}\frac{\partial N_t^p\left(x_t\right)}{\partial h_t^p} \quad (4.D10)
$$

$$
\text{RHS} = -\left(1-\xi\right)\left(N_t^p\left(x_t\right)-U_t\right)^{\xi}\left(J_t\left(x_t\right)-V_t\right)^{-\xi}\frac{\partial J_t\left(x_t\right)}{\partial h_t^p} \quad (4.D11)
$$

Simplifying delivers

$$
\xi J_t\left(x_t\right)\frac{\partial N_t^p\left(x_t\right)}{\partial h_t^p}=-\left(1-\xi\right)\left(N_t^p\left(x_t\right)-U_t\right)\frac{\partial J_t\left(x_t\right)}{\partial h_t^p} \quad (4.D12)
$$

4.E The Non-Stationary Equilibrium

Let's define the average surplus, average idiosyncratic productivity, average wage, and average consumption, conditional on being productive, as $\hat{S}_t = \frac{1}{F(\bar{x}_t)} \int_{x_{min}}^{\bar{x}_t} S_t(x_t) dF(x_t)$, $\hat{x}_t = \frac{1}{F(\bar{x}_t)} \int_{x_{min}}^{\bar{x}_t} x_t dF(x_t)$, $\hat{w}_t^p = \frac{1}{F(\bar{x}_t)} \int_{x_{min}}^{\bar{x}_t} w_t^p(x_t) dF(x_t)$, $\hat{c}_t^p = \frac{1}{F(\bar{x}_t)} \int_{x_{min}}^{\bar{x}_t} c_t^p dF(x_t)$, $\Delta_t^g = N_t^g - U_t$, then we can rewrite the non-stationary equilibrium conditions as

The household

Household's optimal condition (Euler equation):

FOC w.r.t. private consumption:

$$\left[\phi\left(c_t^p\right)^{\frac{\zeta-1}{\zeta}} + (1-\phi)\left(c_t^g\right)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{1-\sigma\zeta}{\zeta-1}} \phi\left(c_t^p\right)^{\frac{-1}{\zeta}} = \varphi_t(1+\tau_c). \tag{4.E1}$$

FOC w.r.t. private saving:

$$\beta\varphi_{t+1}\left[1+(1-\tau_k)\left(r_{t+1}^p - \delta^p\right)\right] = \varphi_t. \tag{4.E2}$$

Aggregate resource constraint:

$$Y_t = c_t^p + K_{t+1}^p - (1-\delta^p)K_t^p + v_t^p \iota^p z_t + n_t^p x_t z_t - u_t s_t z_t + w_t^g n_t^g h_t^g + I_t^g + g_t^g \tag{4.E3}$$

The firm

Aggregate output:

$$Y_t = n_t^p a_t^p \left(k_t^p\right)^{\alpha}\left(h_t^p\right)^{1-\alpha} \tag{4.E4}$$

Aggregate private physical capital:

$$K_t^p = n_t^p k_t^p \tag{4.E5}$$

Optimal physical capital rental rate for the private sector firm:

$$r_t^p = \alpha a_t^p \left(k_t^p\right)^{\alpha-1} \left(h_t^p\right)^{1-\alpha} \tag{4.E6}$$

Average intermediate input cost in productive matches:

$$x_t^a = \hat{x}_t \tag{4.E7}$$

The labor market

Optimal private sector wages:

$$\begin{aligned} w_t^p(x_t)\, h_t^p \quad = \quad & \xi \left[y_t^p - r_t^p k_t^p - x_t z_t + \frac{p_t^p}{q_t} \iota^p z_t \right] \\ & + (1-\xi) \frac{1}{1-\tau_n} \left[s_t z_t + \beta \frac{\varphi_{t+1}}{\varphi_t} p_t^g \Delta_{t+1}^g \right] \end{aligned} \tag{4.E8}$$

Free entry condition:

$$0 = -\iota^p z_t + \beta \frac{\varphi_{t+1}}{\varphi_t} q_t \frac{1-\xi}{1-\xi\tau_n} \hat{S}_{t+1}(x_{t+1})\, F(\bar{x}_{t+1}) \tag{4.E9}$$

Destruction threshold:

$$\bar{x}_t z_t = y_t^p - \tau_n w_t^p(\bar{x}_t) h_t^p - r_t^p k_t^p - s_t z_t + \beta \frac{\varphi_{t+1}}{\varphi_t} \left(1 - p_t^p \xi \frac{1-\tau_n}{1-\xi\tau_n}\right) \hat{S}_{t+1}(x_{t+1}) F(\bar{x}_{t+1}) - \beta \frac{\varphi_{t+1}}{\varphi_t} p_t^g \Delta_{t+1}^g \tag{4.E10}$$

Evolution of unemployment:

$$u_t = \left[1 - p_{t-1}^p F(\bar{x}_t) - p_{t-1}^g\right] u_{t-1} + \left[1 - F(\bar{x}_t)\right] n_{t-1}^p + \lambda^g n_{t-1}^g \tag{4.E11}$$

The probability of leaving unemployment:

$$p_t^{ue} = p_{t-1}^p F(\bar{x}_t) + p_{t-1}^g \tag{4.E12}$$

Evolution of government employment:

$$n_t^g = m_{t-1} \frac{v_{t-1}^g}{v_{t-1}} + (1 - \lambda^g) n_{t-1}^g \tag{4.E13}$$

Evolution of private employment:

$$n_t^p = 1 - n_t^g - u_t \tag{4.E14}$$

Labor market tightness:

$$\theta_t = \frac{v_t^p + v_t^g}{u_t} \tag{4.E15}$$

The matching function:

$$m_t = \eta\,(u_t)^{\mu}\,(v_t)^{1-\mu}\,. \tag{4.E16}$$

Private job finding probability:

$$p_t^p = \frac{m_t}{u_t}\frac{v_t^p}{v_t}. \tag{4.E17}$$

Government job finding probability:

$$p_t^g = \frac{m_t}{u_t}\frac{v_t^g}{v_t}. \tag{4.E18}$$

Government employment value premium:

$$\begin{aligned}\Delta_t^g \;=\;& (1-\tau_n)\,w_t^g h_t^g - s_t z_t + \beta\,\frac{\varphi_{t+1}}{\varphi_t} \\ & \left[\left(1-\lambda^g - p_t^g\right)\Delta_{t+1}^g - p_t^p\,\frac{\xi\,(1-\tau_n)}{1-\xi\,\tau_n}\hat{S}_{t+1}\,(x_{t+1})\,F\,(\bar{x}_{t+1})\right]\end{aligned} \tag{4.E19}$$

The joint surplus:

$$\begin{aligned}\hat{S}_t\,(x_t) \;=\;& y_t^p - \tau_n w_t^p\,(x_t)\,h_t^p - r_t^p k_t^p - x_t z_t - s_t z_t + \beta\,\frac{\varphi_{t+1}}{\varphi_t} \\ & \left(1 - p_t^p\,\xi\,\frac{1-\tau_n}{1-\xi\,\tau_n}\right)\int_{x_{min}}^{\bar{x}_{t+1}} S_{t+1}\,(x_{t+1})\,dF\,(x_{t+1}) - \beta\,\frac{\varphi_{t+1}}{\varphi_t}\,p_t^g\,\Delta_{t+1}^g\end{aligned} \tag{4.E20}$$

The cumulative distribution function of the non-productive idiosyncratic input cost:

$$F\left(\bar{x}_t\right) = cdf\left('exp', \bar{x}_t, \chi\right) \tag{4.E21}$$

The government

Government production:

$$c_t^g = a_t^g \left(K_t^g\right)^{\gamma} \left(n_t^g h_t^g\right)^{1-\gamma} - \iota^g v_t^g \tag{4.E22}$$

Public physical capital evolution:

$$K_{t+1}^g = \left(1-\delta^g\right) K_t^g + I_t^g \tag{4.E23}$$

Government budget constraint:

$$w_t^g n_t^g h_t^g + I_t^g + g_t^g = \tau_c c_t^p + \tau_n \left(W_t^p + W_t^g\right) + \tau_k \left(r_t^p - \delta^p\right) K_t^p - u_t s_t + T_t + D_t \tag{4.E24}$$

Government sector wage:

$$w_t^g = \left(1+\pi^g\right) w_t^p \tag{4.E25}$$

Government hours worked:

$$h_t^g = GWE_t / \left(w_t^p n_t^g \right) \tag{4.E26}$$

Value of home production:

$$s_t = x^b a_t^p \left(k_t^p \right)^{\alpha} \left(h_t^p \right)^{1-\alpha} \tag{4.E27}$$

4.F The Stationary Equilibrium

In this section, we write down the stationary equilibrium conditions that characterize the model. Define κ_t as the growth rate of TFP, i.e., $e^{\kappa_t} = \frac{a_t^p}{a_{t-1}^p} = \frac{a_t^g}{a_{t-1}^g}$, and the TFP factor as $\left(a_t^p\right)^{\frac{1}{1-\alpha}}$, where we assume that the technology in the government sector grows at the same rate as TFP to guarantee the existence of the balanced growth path.

To get the stationary equilibrium, we employ z_t, a variable that grows at the average growth rate of the TFP factor along the balanced growth path, $\frac{\bar{\kappa}}{1-\alpha}$. The growing variables in the economy can be detrended as stationary by dividing them by z_t as follows:

$$\tilde{Y}_t = \frac{Y_t}{z_t}, \tilde{K}_t^p = \frac{K_t^p}{z_t}, \tilde{c}_t^p = \frac{c_t^p}{z_t}, \tilde{c}_t^g = \frac{c_t^g}{z_t}, \tilde{k}_t^p = \frac{k_t^p}{z_t}, \tilde{y}_t^p = \frac{y_t^p}{z_t}$$

$$\tilde{K}_t^g = \frac{K_t^g}{z_t}, \tilde{I}_t^g = \frac{I_t^g}{z_t}, \tilde{g}_t^g = \frac{g_t^g}{z_t}, \tilde{w}_t^g = \frac{w_t^g}{z_t}, \tilde{w}_t^p = \frac{\hat{w}_t^p}{z_t}, \tilde{\Delta}_t^g = \frac{\Delta_t^g}{z_t}$$

As we assume that technology is labor augmenting, and the production function of the private sector firm is specified as $y_t^p = a_t^p \left(k_t^p\right)^{\alpha} \left(h_t^p\right)^{1-\alpha}$. We define the detrended TFP as $\tilde{a}_t^p \equiv \frac{a_t^p}{z_t^{1-\alpha}} = \tilde{a}_{t-1}^p e^{(\kappa_t - \bar{\kappa})}$. In simulation, we normalize the initial technology to be one, i.e., $a_0^p = \tilde{a}_0^p = 1$ and $a_0^g = \tilde{a}_0^g = 1$.

Define the stationary average surplus, average idiosyncratic productivity, average wage, and average consumption, and public sector working premium, conditional on being productive, as $\tilde{S}_t = \frac{1}{F(\bar{x}_t)} \frac{1}{z_t} \int_{x_{min}}^{\bar{x}_t} S_t(x_t)\, dF(x_t)$, $\tilde{w}_t^p = \frac{1}{F(\bar{x}_t)} \frac{1}{z_t} \int_{x_{min}}^{\bar{x}_t} w_t^p(x_t)\, dF(x_t)$, $\tilde{c}_t^p = \frac{1}{F(\bar{x}_t)} \frac{1}{z_t} \int_{x_{min}}^{\bar{x}_t} c_t^p dF(x_t)$, $\tilde{c}_t^g = \frac{1}{z_t} c_t^g$, $\tilde{\Delta}_t^g = \frac{1}{z_t}\left(N_t^g - U_t\right)$.

We can define a perfect foresight stationary competitive equilibrium, for a given path of exogenous TFP growth rate $\left\{\tilde{a}_t^p, \tilde{a}_t^g, h_t^p\right\}_{t=0}^{\infty}$, government policy $\left\{\tau_n, \tau_k, \chi_t, v_t^g\right\}_{t=0}^{\infty}$, $\left\{h_t^g, \tilde{I}_t^p, \tilde{g}_t^g, s_t\right\}_{t=0}^{\infty}$, and K_0, as $\left\{\tilde{c}_t^p, \tilde{c}_t^g, \tilde{K}_{t+1}^p, \tilde{K}_t^g, \tilde{k}_t^p, n_t^p, n_t^g, m_t\right\}_{t=0}^{\infty}$, $\left\{h_t^g, p_t^p, p_t^g, p_t^{ue}, u_t\right\}_{t=0}^{\infty}$, $\left\{v_t^p, \theta_t, \bar{x}_t, x_t^a\right\}_{t=0}^{\infty}$, and $\left\{\tilde{Y}_t, \tilde{S}_t, \varphi_t, r_t^p, \tilde{w}_t^p, \tilde{w}_t^g, \tilde{T}_t, \tilde{\Delta}_t^g, F(\bar{x}_t)\right\}_{t=0}^{\infty}$ which satisfy:

The household

Household's optimal condition (Euler equation):

FOC w.r.t. private consumption:

$$\left[\phi\left(\tilde{c}_t^p\right)^{\frac{\zeta-1}{\zeta}}+(1-\phi)\left(\tilde{c}_t^g\right)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{1-\sigma\zeta}{\zeta-1}}\phi\left(\tilde{c}_t^p\right)^{\frac{-1}{\zeta}} = \tilde{\varphi}_t\left(1+\tau_c\right). \tag{4.F1}$$

FOC w.r.t. private saving:

$$\beta\frac{\tilde{\varphi}_{t+1}}{\tilde{\varphi}_t}e^{\frac{\bar{\kappa}}{1-\alpha}}\left[1+(1-\tau_k)\left(r_{t+1}^p-\delta^p\right)\right]=1. \tag{4.F2}$$

Aggregate resource constraint:

$$\tilde{Y}_t=\tilde{c}_t^p+\tilde{K}_t^p-(1-\delta^p)\tilde{K}_{t-1}^p e^{-\frac{\bar{\kappa}}{1-\alpha}}+v_t^p\iota^p+n_t^p x_t^a-u_t\tilde{s}_t+\tilde{w}_t^g n_t^g h_t^g+\tilde{I}_t^g+\tilde{g}_t^g \tag{4.F3}$$

The firm

Aggregate output:

$$\tilde{Y}_t=\tilde{a}_{t-1}^p e^{(\kappa_t-\bar{\kappa})}n_t^p\left(\tilde{k}_t^p\right)^{\alpha}\left(h_t^p\right)^{1-\alpha} \tag{4.F4}$$

Aggregate private physical capital:

$$\tilde{K}_{t-1}^p e^{-\frac{\bar{\kappa}}{1-\alpha}}=n_t^p\tilde{k}_t^p \tag{4.F5}$$

Optimal physical capital rental rate for the private sector firm:

$$r_t^p = \alpha \tilde{a}_{t-1}^p e^{(\kappa_t - \bar{\kappa})} \left(\tilde{k}_t^p\right)^{\alpha-1} \left(h_t^p\right)^{1-\alpha} \tag{4.F6}$$

Average intermediate input cost in productive matches:

$$x_t^a = \frac{1}{F(\bar{x}_t)} \int_{x_{min}}^{\bar{x}_t} x_t dF(x_t) \tag{4.F7}$$

The labor market

Optimal private sector wages:

$$\begin{aligned} \tilde{w}_t^p(x_t) h_t^p &= \xi \left[\tilde{a}_{t-1}^p e^{(\kappa_t - \bar{\kappa})} \left(\tilde{k}_t^p\right)^{\alpha} \left(h_t^p\right)^{1-\alpha} - r_t^p \tilde{k}_t^p - x_t^a + \frac{p_t^p}{q_t} \iota^p\right] \\ &\quad + (1-\xi) \frac{1}{1-\tau_n} \left[s_t + \beta \frac{\tilde{\varphi}_{t+1}}{\tilde{\varphi}_t} e^{\frac{\bar{\kappa}}{1-\alpha}} p_t^g \tilde{\Delta}_{t+1}^g\right] \end{aligned} \tag{4.F8}$$

Creation condition:

$$0 = -\iota^p + \beta \frac{\tilde{\varphi}_{t+1}}{\tilde{\varphi}_t} e^{\frac{\bar{\kappa}}{1-\alpha}} q_t \frac{1-\xi}{1-\xi\tau_n} \tilde{S}_{t+1}(x_{t+1}) F(\bar{x}_{t+1}) \tag{4.F9}$$

Destruction threshold:

$$\begin{aligned} \bar{x}_t &= \tilde{a}_{t-1}^p e^{(\kappa_t - \bar{\kappa})} \left(\tilde{k}_t^p\right)^{\alpha} \left(h_t^p\right)^{1-\alpha} - \tau_n \tilde{w}_t^p(\bar{x}_t) h_t^p - r_t^p \tilde{k}_t^p - s_t \\ &\quad + \beta \frac{\tilde{\varphi}_{t+1}}{\tilde{\varphi}_t} e^{\frac{\bar{\kappa}}{1-\alpha}} \left(1 - p_t^p \xi \frac{1-\tau_n}{1-\xi\tau_n}\right) \tilde{S}_{t+1}(x_{t+1}) F(\bar{x}_{t+1}) \\ &\quad - \beta \frac{\tilde{\varphi}_{t+1}}{\tilde{\varphi}_t} e^{\frac{\bar{\kappa}}{1-\alpha}} p_t^g \tilde{\Delta}_{t+1}^g \end{aligned} \tag{4.F10}$$

Evolution of unemployment:

$$u_t = (1 - p_t^{ue})\, u_{t-1} + [1 - F(\bar{x}_t)]\, n_{t-1}^p + \lambda^g n_{t-1}^g \tag{4.F11}$$

The probability of leaving unemployment:

$$p_t^{ue} = p_{t-1}^p F(\bar{x}_t) + p_{t-1}^g \tag{4.F12}$$

Evolution of government employment:

$$n_t^g = m_{t-1} \frac{v_{t-1}^g}{v_{t-1}} + (1 - \lambda^g)\, n_{t-1}^g \tag{4.F13}$$

Evolution of private employment:

$$n_t^p = 1 - n_t^g - u_t \tag{4.F14}$$

Market tightness:

$$\theta_t = \frac{v_t^p + v_t^g}{u_t} \tag{4.F15}$$

The matching function:

$$m_t = \eta\, (u_t)^{\mu}\, (v_t)^{1-\mu}. \tag{4.F16}$$

Private job finding probability:

$$p_t^p = \frac{m_t}{u_t}\frac{v_t^p}{v_t}. \tag{4.F17}$$

Government job finding probability:

$$p_t^g = \frac{m_t}{u_t}\frac{v_t^g}{v_t}. \tag{4.F18}$$

Government employment value premium:

$$\begin{aligned}\tilde{\Delta}_t^g &= (1-\tau_n)\,\tilde{w}_t^g h_t^g - s_t + \beta\frac{\tilde{\varphi}_{t+1}}{\tilde{\varphi}_t}e^{\frac{\bar{\kappa}}{1-\alpha}} \\ &\left[\left(1-\lambda^g - p_t^g\right)\tilde{\Delta}_{t+1}^g - p_t^p\frac{\xi\,(1-\tau_n)}{1-\xi\,\tau_n}\tilde{S}_{t+1}\,(x_{t+1})\,F\,(\bar{x}_{t+1})\right]\end{aligned} \tag{4.F19}$$

The joint surplus:

$$\begin{aligned}\tilde{S}_t\,(x_t) &= \tilde{y}_t^p - \tau_n\tilde{w}_t^p\,(x_t)\,h_t^p - r_t^p\tilde{k}_t^p - x_t - s_t + \beta\frac{\tilde{\varphi}_{t+1}}{\tilde{\varphi}_t}e^{\frac{\bar{\kappa}}{1-\alpha}} \\ &\left(1 - p_t^p\xi\frac{1-\tau_n}{1-\xi\,\tau_n}\right)\int_{x_{min}}^{\bar{x}_{t+1}}\tilde{S}_{t+1} \\ &(x_{t+1})\,dF\,(x_{t+1}) - \beta\frac{\tilde{\varphi}_{t+1}}{\tilde{\varphi}_t}e^{\kappa}p_t^g\tilde{\Delta}_{t+1}^g\end{aligned} \tag{4.F20}$$

The cumulative distribution function of the non-productive idiosyncratic input cost

$$F\left(\bar{x}_t\right)=cdf\left('exp',\bar{x}_t,\chi\right) \tag{4.F21}$$

The government

Government production:

$$\tilde{c}_t^g=\tilde{a}_{t-1}^g e^{(\kappa_t-\bar{\kappa})}\left(\tilde{K}_t^g\right)^\gamma\left(n_t^g h_t^g\right)^{1-\gamma}-\iota^g v_t^g \tag{4.F22}$$

Public physical capital evolution:

$$\tilde{K}_{t+1}^g e^{\frac{\bar{\kappa}}{1-\alpha}}=\left(1-\delta^g\right)\tilde{K}_t^g+\tilde{I}_t^g \tag{4.F23}$$

Government budget constraint:

$$\tilde{w}_t^g n_t^g h_t^g+\tilde{I}_t^g+\tilde{g}_t^g=\tau_n c_t^p+\tau_n\left(\tilde{w}_t^p n_t^p h_t^p+\tilde{w}_t^g n_t^g h_t^g\right)+\tau_k\left(r_t^p-\delta^p\right)\tilde{K}_t^p-u_t\tilde{s}_t+\tilde{T}_t+\tilde{D}_t \tag{4.F24}$$

Government sector wage:

$$\tilde{w}_t^g=\left(1+\pi^g\right)\tilde{w}_t^p \tag{4.F25}$$

Government hours worked:

$$h_t^g=GWE_t/\left(\tilde{w}_t^p n_t^g\right) \tag{4.F26}$$

Value of home production:

$$\tilde{s}_t = x^b \tilde{a}^p_{t-1} e^{(\kappa_t - \bar{\kappa})} \left(\tilde{k}^p_t\right)^{\alpha} \left(h^p_t\right)^{1-\alpha} \tag{4.F27}$$

4.G The Steady State of The Stationary Equilibrium

$\left\{c_t^p, c_t^g, K_{t+1}^p, K_t^g, k_t^p, n_t^p, n_t^g, m_t, h_t^g, p_t^p, p_t^g, p_t^{ue}, u_t, v_t^p, \theta_t, \bar{x}_t, x_t^a, Y_t, S_t, \varphi_t, r_t^p\right\}_{t=0}^{\infty}$, $\left\{w_t^p\right\}_{t=0}^{\infty}$, and $\left\{w_t^p, w_t^g, T_t, \Delta_t^g, F\left(\bar{x}_t\right)\right\}_{t=0}^{\infty}$ are the 27 endogenous variables that we need to solve from the following 27 equations. Given the path of exogenous TFP growth rate $\left\{\tilde{a}_t^p, \tilde{a}_t^g, h_t^p\right\}_{t=0}^{\infty}$, government policy $\left\{\tau_n, \tau_k, \chi_t, v_t^g, G\tilde{W}E_t, \tilde{I}_t^p, \tilde{g}_t^g, s_t\right\}_{t=0}^{\infty}$, and K_0.

$$n^p = 1 - n^g - u \tag{4.G1}$$

$$u = \left(1 - p^{ue}\right) u + \left[1 - F\left(\bar{x}\right)\right] n^p + \lambda^g n^g \tag{4.G2}$$

$$n^g = m^g + \left(1 - \lambda^g\right) n^g = m \frac{v^g}{v} + \left(1 - \lambda^g\right) n^g \tag{4.G3}$$

$$p^{ue} = p^p F\left(\bar{x}\right) + p^g \tag{4.G4}$$

$$p^p = \frac{m}{u} \frac{v^p}{v^p + v^g} \tag{4.G5}$$

$$p^g = \frac{m}{u} \frac{v^g}{v^p + v^g} \tag{4.G6}$$

$$m = \eta u \left(\theta\right)^{1-\mu}. \tag{4.G7}$$

$$\theta = \frac{v^p + v^g}{u} \tag{4.G8}$$

$$\bar{x} = a^p e^{(\kappa-\bar{\kappa})} \left(\tilde{k}^p\right)^{\alpha} \left(h^p\right)^{1-\alpha} - \tau_n w^p \left(\bar{x}\right) h^p - r^p k^p - s$$
$$+\beta e^{\frac{\bar{\kappa}}{1-\alpha}} \frac{\varphi}{\varphi} \left(1 - p^p \xi \frac{1-\tau_n}{1-\xi\tau_n}\right) S\left(x\right) F\left(\bar{x}\right) - \beta e^{\frac{\bar{\kappa}}{1-\alpha}} \frac{\varphi}{\varphi} p^g \tilde{\Delta}^g \tag{4.G9}$$

$$\tilde{\Delta}^g = \left(1-\tau_n\right) w^g h^g - s + \beta \frac{\varphi}{\varphi} e^{\frac{\bar{\kappa}}{1-\alpha}}$$
$$\left[\left(1 - \lambda^g - p^g\right) \tilde{\Delta}^g - p^p \frac{\xi\left(1-\tau_n\right)}{1-\xi\tau_n} S\left(x\right) F\left(\bar{x}\right)\right] \tag{4.G10}$$

$$\left[\phi \left(c^p\right)^{\frac{\zeta-1}{\zeta}} + \left(1-\phi\right) \left(c^g\right)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{1-\sigma\zeta}{\zeta-1}} \phi \left(c^p\right)^{\frac{-1}{\zeta}} = \varphi \left(1+\tau_c\right). \tag{4.G11}$$

$$\beta \frac{\varphi}{\varphi} e^{\frac{\bar{\kappa}}{1-\alpha}} \left[1 + \left(1-\tau_k\right)\left(r^p - \delta^p\right)\right] = 1. \tag{4.G12}$$

$$Y = c^p + K^p - (1-\delta^p) K^p e^{-\frac{\bar{\kappa}}{1-\alpha}} + v^p \iota^p + n^p x^a - us + w^g n^g h^g + I^g + g^g \tag{4.G13}$$

$$Y = a^p e^{(\kappa-\bar{\kappa})} n^p \left(k^p\right)^{\alpha} \left(h^p\right)^{1-\alpha} \tag{4.G14}$$

$$K^p e^{-\frac{\bar{\kappa}}{1-\alpha}} = n^p k^p \tag{4.G15}$$

$$r^p = \alpha a^p e^{(\kappa-\bar{\kappa})} \left(k^p\right)^{\alpha-1} \left(h^p\right)^{1-\alpha} \tag{4.G16}$$

$$x^{a}=\frac{1}{F\left(\bar{x}\right)}\int_{x_{min}}^{\bar{x}}xdF\left(x\right) \tag{4.G17}$$

$$\begin{aligned} w^{p}\left(x\right)h^{p} &= \xi\left[a^{p}e^{\left(\kappa-\bar{\kappa}\right)}\left(k^{p}\right)^{\alpha}\left(h^{p}\right)^{1-\alpha}-r^{p}k^{p}-x^{a}+\frac{p^{p}}{q}\iota^{p}\right] \\ &+\left(1-\xi\right)\frac{1}{1-\tau_{n}}\left[s+\beta e^{\frac{\bar{\kappa}}{1-\alpha}}\frac{\varphi}{\varphi}p^{g}\tilde{\Delta}^{g}\right] \end{aligned} \tag{4.G18}$$

$$0=-\iota^{p}+\beta e^{\frac{\bar{\kappa}}{1-\alpha}}\frac{\varphi}{\varphi}\frac{m}{v^{p}+v^{g}}\frac{1-\xi}{1-\xi\tau_{n}}S\left(x\right)F\left(\bar{x}\right) \tag{4.G19}$$

$$c^{g}=a^{g}e^{\left(\kappa-\bar{\kappa}\right)}\left(K^{g}\right)^{\gamma}\left(n^{g}h^{g}\right)^{1-\gamma}-\iota^{g}v^{g} \tag{4.G20}$$

$$K^{g}e^{\frac{\bar{\kappa}}{1-\alpha}}=\left(1-\delta^{g}\right)K^{g}+I^{g} \tag{4.G21}$$

$$w^{g}n^{g}h^{g}+I^{g}+g^{g}=\tau_{c}c^{p}+\tau_{n}\left(w^{p}n^{p}h^{p}+w^{g}n^{g}h^{g}\right)+\tau_{k}\left(r^{p}-\delta^{p}\right)K^{p}-us+T+D \tag{4.G22}$$

$$w^{g}=\left(1+\pi^{g}\right)w^{p} \tag{4.G23}$$

$$F=cdf\left('exp',\bar{x},\chi\right) \tag{4.G24}$$

$$S=\left(1-\xi\tau_{n}\right)\left(\bar{x}-x^{a}\right) \tag{4.G25}$$

$$h^{g}=GWE/\left(\tilde{w}^{p}n^{g}\right) \tag{4.G26}$$

$$s = x^b a^p \left(k^p\right)^\alpha \left(h^p\right)^{1-\alpha} \tag{4.G27}$$

4.H The Dynamic Version of The Model

$$n_t^p = 1 - n_t^g - u_t \tag{4.H1}$$

$$F(\bar{x}_t) = \frac{\left[(1-p_t^{ue})\,u_{t-1} + n_{t-1}^p + \lambda^g n_{t-1}^g - u_t\right]}{n_{t-1}^p} \tag{4.H2}$$

$$n_t^g = m_{t-1}\frac{v_{t-1}^g}{v_{t-1}^p + v_{t-1}^g} + (1-\lambda^g)\,n_{t-1}^g \tag{4.H3}$$

$$p_t^{ue} = p_{t-1}^p F(\bar{x}_t) + p_{t-1}^g \tag{4.H4}$$

$$p_t^p = \frac{m_t}{u_t}\frac{v_t^p}{v_t}. \tag{4.H5}$$

$$p_t^g = \frac{m_t}{u_t}\frac{v_t^g}{v_t}. \tag{4.H6}$$

$$m_t = \eta u_t (\theta_t)^{1-\mu}. \tag{4.H7}$$

$$\theta_t = \frac{v_t^p + v_t^g}{u_t} \tag{4.H8}$$

$$\begin{aligned}
\bar{x}_t \;=\;& \tilde{a}_t^p \left(\tilde{k}_t^p\right)^{\alpha} \left(h_t^p\right)^{1-\alpha} - \tau_n \tilde{w}_t^p(\bar{x}_t)\, h_t^p - r_t^p \tilde{k}_t^p - s_t \\
&+\beta\frac{\tilde{\varphi}_{t+1}}{\tilde{\varphi}_t} e^{\frac{\bar{\kappa}}{1-\alpha}} \left(1 - p_t^p \xi \frac{1-\tau_n}{1-\xi\tau_n}\right) \tilde{S}_{t+1}(x_{t+1})\, F(\bar{x}_{t+1}) \\
&-\beta\frac{\tilde{\varphi}_{t+1}}{\tilde{\varphi}_t} e^{\frac{\bar{\kappa}}{1-\alpha}} p_t^g \tilde{\Delta}_{t+1}^g
\end{aligned} \tag{4.H9}$$

$$\tilde{\Delta}_t^g = (1-\tau_n)\,\tilde{w}_t^g h_t^g - s_t + \beta\frac{\tilde{\varphi}_{t+1}}{\tilde{\varphi}_t} e^{\frac{\bar{\kappa}}{1-\alpha}} \left[\left(1-\lambda^g - p_t^g\right)\tilde{\Delta}_{t+1}^g - p_t^p \frac{\xi\,(1-\tau_n)}{1-\xi\,\tau_n}\tilde{S}_{t+1}\,(x_{t+1})\,F\,(\bar{x}_{t+1})\right] \tag{4.H10}$$

$$\left[\phi\left(\tilde{c}_t^p\right)^{\frac{\zeta-1}{\zeta}} + (1-\phi)\left(\tilde{c}_t^g\right)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{1-\sigma\zeta}{\zeta-1}} \phi\left(\tilde{c}_t^p\right)^{\frac{-1}{\zeta}} = \tilde{\varphi}_t\,(1+\tau_c)\,. \tag{4.H11}$$

$$\beta\frac{\tilde{\varphi}_{t+1}}{\tilde{\varphi}_t} e^{\frac{\bar{\kappa}}{1-\alpha}}\left[1+(1-\tau_k)\left(r_{t+1}^p - \delta^p\right)\right] = 1. \tag{4.H12}$$

$$\tilde{Y}_t = \tilde{c}_t^p + \tilde{K}_t^p - (1-\delta^p)\tilde{K}_{t-1}^p e^{-\frac{\bar{\kappa}}{1-\alpha}} + v_t^p \iota^p + n_t^p x_t^a - u_t \tilde{s}_t + \tilde{w}_t^g n_t^g h_t^g + \tilde{I}_t^g + \tilde{g}_t^g \tag{4.H13}$$

$$\tilde{Y}_t = \tilde{a}_t^p n_t^p \left(\tilde{k}_t^p\right)^{\alpha}\left(h_t^p\right)^{1-\alpha} \tag{4.H14}$$

$$\tilde{K}_{t-1}^p e^{-\frac{\bar{\kappa}}{1-\alpha}} = n_t^p \tilde{k}_t^p \tag{4.H15}$$

$$r_t^p = \alpha\tilde{a}_t^p\left(\tilde{k}_t^p\right)^{\alpha-1}\left(h_t^p\right)^{1-\alpha} \tag{4.H16}$$

$$x_t^a = \frac{1}{F\,(\bar{x}_t)}\int_{x_{min}}^{\bar{x}_t} x_t dF\,(x_t) \tag{4.H17}$$

$$\begin{aligned}\tilde{w}_t^p(x_t)\,h_t^p &= \xi\left[\tilde{a}_t^p\left(\tilde{k}_t^p\right)^{\alpha}\left(h_t^p\right)^{1-\alpha} - r_t^p\tilde{k}_t^p - x_t^a + \frac{p_t^p}{q_t}\iota^p\right]\\ &\quad + (1-\xi)\,\frac{1}{1-\tau_n}\left[s_t + \beta\,\frac{\tilde{\varphi}_{t+1}}{\tilde{\varphi}_t}e^{\frac{\bar{\kappa}}{1-\alpha}}p_t^g\tilde{\Delta}_{t+1}^g\right]\end{aligned} \tag{4.H18}$$

$$0 = -\iota^p + \beta\,\frac{\tilde{\varphi}_{t+1}}{\tilde{\varphi}_t}e^{\frac{\bar{\kappa}}{1-\alpha}}q_t\,\frac{1-\xi}{1-\xi\,\tau_n}\tilde{S}_{t+1}(x_{t+1})\,F(\bar{x}_{t+1}) \tag{4.H19}$$

$$\tilde{c}_t^g = \tilde{a}_t^g\left(\tilde{K}_t^g\right)^{\gamma}\left(n_t^g h_t^g\right)^{1-\gamma} - \iota^g v_t^g \tag{4.H20}$$

$$\tilde{K}_t^g e^{\frac{\bar{\kappa}}{1-\alpha}} = (1-\delta^g)\,\tilde{K}_{t-1}^g + \tilde{I}_t^g \tag{4.H21}$$

$$\tilde{w}_t^g n_t^g h_t^g + \tilde{I}_t^g + \tilde{g}_t^g = \tau_c c_t^p + \tau_n\left(\tilde{w}_t^p n_t^p h_t^p + \tilde{w}_t^g n_t^g h_t^g\right) + \tau_k\left(r_t^p - \delta^p\right)\tilde{K}_t^p - u_t\tilde{s}_t + \tilde{T}_t + \tilde{D}_t \tag{4.H22}$$

$$\tilde{w}_t^g = (1+\pi^g)\,\tilde{w}_t^p \tag{4.H23}$$

$$F(\bar{x}_t) = cdf\left('exp', \bar{x}_t, \chi\right) \tag{4.H24}$$

$$\tilde{S}_t(x_t) = (1-\tau_n\xi)(\bar{x}_t - x_t^a) \tag{4.H25}$$

$$h_t^g = GWE_t/\left(\tilde{w}_t^p n_t^g\right) \tag{4.H26}$$

$$s_t = x^b \tilde{a}_t^p \left(\tilde{k}_t^p\right)^{\alpha} \left(h_t^p\right)^{1-\alpha} \tag{4.H27}$$

Chapter 5

Labor Mobility Barriers, Public Education Expenditure, and China's Enlarging Interregional Income Inequality

The urban-rural income inequality in China has been increasing significantly since 1978. Labor mobility barriers and urban-biased government education expenditures have been considered as two main determinants of this enlarging interregional income inequality. To investigate how these two factors affect the urban-rural income inequality, we develop a two-region growth model, where labor mobility barriers affect the cost of migration across regions, while government education expenditures influence the accumulation of regional human capital. We characterize the equilibrium paths of regional mean income, with which we evaluate the impacts of reducing labor mobility barriers and reallocating government education spending on interregional income inequality, measured by the ratio of urban to rural mean incomes, through comparative dynamics analysis. We find that reallocating government education spending more equally mitigates the interregional income inequality, while only reducing the labor mobility barriers does not necessarily decrease the urban-rural income inequality, and the combination of these two policies is more likely to reduce the interregional income inequalities. Our analysis suggests that reallocating government education resources more equally across regions could be very important in mitigating the enlarging urban-rural income inequality in China.

5.1 Introduction

The growth rate of real gross domestic product (GDP) per capita in China has been around 9% per year since 1978 (e.g., Lin, 2012 and NBS, 2011). Meanwhile, the overall income inequality, measured by Gini coefficient, has increased from 0.16 in 1978 to 0.48 in 2008 (e.g., Zhu and Wan, 2012 and He, 2012). In addition, the interregional[1] income inequality, captured by the ratio of urban mean income to rural mean income, has also increased from 1.82 in 1983 to 3.31 in 2008. This experience of rising income inequality during China's rapid growth process has been intensively examined by many studies (e.g., Veloso, 2011 and Song et al., 2011).

The labor mobility barriers, generated by *hukou* system, have been widely considered as one of the main sources of interregional income inequality in China (e.g., Cai et al., 2002; Liu, 2005; Whalley and Zhang, 2007; and Fu, 2013). As labor mobility restrictions restrain the free migration of labor across regions, and thus distort the allocation and incomes of labor. Moreover, the regulations associated *hukou*, in particular, the highly restricted access to the better urban education resources for rural children, tends to amplify the human capital gap and hence the income difference across regions.

Another important determinant of this enlarging income inequality has been the allocation of government education spending across regions (e.g., Treiman, 2012; Wu, 2011; Wang et al., 2011; Chen et al., 2010; and Zhu and Ma, 2009), which directly affects the quality and level of regional education, and thus the urban-rural income inequality. Figure 5.1 demonstrates that the government education expenditure per urban student is almost twice as much as that per rural student.

To better tackle the problem of rising urban-rural income inequality, policy mak-

[1] Interregional means urban-rural, where the administrative and geographic criteria of urban and rural areas are different, we follow the administrative criteria in defining urban and rural, which are consistent with the data employed in describing the interregional income inequality later.

ers need to know, at least qualitatively, what would happen to the interregional income inequality if government gradually eliminates the labor mobility barriers? How would urban-rural income inequality change if government reallocates the education resources? Moreover, what will be the scenario if government removes both distortions at the same time? To answer these questions, we need a framework where the characters of labor mobility barriers and government education spending could be examined simultaneously. However, as far as we know, there is no such theoretical framework which could be directly employed to examine their roles simultaneously.

The objective of this paper is to construct a theoretical framework which could be employed to evaluate the impacts of simultaneously removing the labor mobility barriers and changing the allocation of government education resources on interregional income inequality, and to further qualitatively investigate these impacts within this new framework.

To achieve this target, we build an economic growth model with two regions: urban area and rural area, migration between the two regions are costly, which is affected by the parameter capturing the character of labor mobility barriers. Moreover, there exist overlapping generations within each region, individuals are heterogenous with respect to parental human capita level and innate learning ability. Individuals accumulate their human capital when they are children, and their human capital formation is affected by government education spending per student, where the character of allocating government education resources shows up.

With the stationarity assumption of learning ability distribution, the log normal assumption of initial parental human capital distribution, and several tractability specifications of functional forms, we derive the mean income for each region through aggregation under two scenarios: segregation and integration. The interregional income inequality is measured by the ratio of urban to rural mean incomes. The sources of income inequality within each region come from heterogeneity in learning ability and parental human capital, while across regions the inequality sources originate from the differences in government education spending and human capital level.

Under segregation, there is no migration across regions. We demonstrate that reallocating the government spending more equally across regions does not affect the intraregional income inequality, but helps to alleviate the interregional income inequality.

Under integration, migration occurs due to the reduced migration cost, which is implemented by decreasing the policy parameter that captures the character of labor mobility restrictions. Our comparative dynamics analysis reveals that simply removing labor mobility barriers does not necessarily alleviate the interregional income inequality, as the mean income of the rural migrants working in the urban area declines compared with what they earn before the removal although the mean income of rural stayers increases. However, the policy combination of simultaneously removing the labor mobility barriers and reallocating the education resources more equally would be more likely to reduce the interregional income inequality since reallocating government spending tends to increase the mean income of the rural migrants, which mitigates the negative impacts of removing labor mobility barriers on the mean income of rural migrants. Our qualitative analysis has strong implications on what the Chinese government is doing now, i.e., they are gradually erasing the difference between urban *hukou* and rural *hukou*, as a single policy instrument which is not enough to mitigate the rising interregional income inequality, thus the reallocation of government education resources should also be considered.

The rest of this paper is organized as follows: section 5.2 reviews the literature and articulates the contributions of our study. Section 5.3 documents the relevant facts of the Chinese economy. Section 5.4 describes the framework of the model. Section 5.5 examines the effects of reallocating government education resources under segregation. While section 5.6 investigates the impacts from simultaneously removing labor mobility barriers and redistributing education resources. Section 5.7 concludes and discusses the directions of future research.

5.2 Literature Review

This paper is related to the stream of literature that examines the character of labor mobility barriers, generated by *hukou* system, in China's rising urban-rural income inequality, for example, Cai et al. (2002), Liu (2005), Whalley and Zhang (2007), and Fu (2013). This category of literature concentrates on the argument that labor mobility barriers distort the allocation of labors, which affects the regional average income, and hence urban-rural income inequality. Moreover, the presence of labor mobility barrier and the associated regulations also exert negative impacts on the accumulation of human capital in the rural area.

It is very difficult for rural children to benefit from the better education resources in urban areas as their parents are not allowed to freely migrate[2], which is essentially the policy interactions of government education spending and labor mobility barriers. As highlighted by Zhu and Wan (2012), little attention has been devoted to evaluate the impacts of their interactions on income inequality. But economists and policy makers need to know what would happen to the interregional income inequality if government changes these two policies simultaneously, this paper attempts to explore this question theoretically, which is one of our contributions.

Our paper is also related to the stream of literature that investigates the impact of government spending on the enlarging urban-rural income inequality during China's rapid growth process, such as Chen et al. (2010), Wang et al. (2011), Wu et al. (2008), Wu (2011), and Treiman (2012). The channel that government education spending affects urban-rural income inequality, i.e., through affecting the regional human capital level, has been highlighted in this stream of literature. However, most of these studies concentrates on investigating the impacts of government education spending on interregional inequality, and the character of labor mobility barriers is overlooked, thus the impacts of changing

[2]For example, "the *hukou* system requires all students to take their college entrance exams in the place of their original *hukou* registration regardless of their current residence and school location." (e.g., Cai, 2011).

government education spending polices and labor mobility simultaneously were not studied in this literature. To overcome this drawback in this stream of literature, we develop a two regions model, where the labor mobility barrier is modeled such that it affects the migration cost.

Another stream of literature, which provides empirical evidence on the nexus among human capital difference, regional income inequality, and economic growth, such as Wei et al. (2001), Zhai et al. (2006), and Liu et al. (2011), is also related with our study. These studies empirically investigate how important is human capital[3] in determining the interregional income inequality, but they didn't provide a theoretical framework to characterize the relationship between human capital and interregional income inequality. This shortcoming in the literature also motivated us to develop a theoretical framework which could be employed to examine the relationships between human capital and income inequality across regions.

Our research contributes to the literature mainly from two aspects: on the one hand, we construct a framework within which the impacts of government education expenditure, labor mobility barrier, and their interaction on urban-rural income inequality could be characterized and evaluated; on the other hand, we qualitatively characterize the sources of urban-rural income inequality, and how government spending policies and labor market policies as well as their interaction affect the interregional income inequalities. In addition, we want to highlight that our framework is motivated by the stylized facts in China, however, it could also be applied to emerging economies which share the similar government spending and labor market characteristics as in China.

[3]Concerning what determines human capital production, Sun (2011) documented an evidence of intergenerational mobility of education and occupation in China. However, quite few theoretical studies have incorporated this interesting and important finding in specifying the human capital production function.

5.3 The Motivating Facts of The Chinese Economy Since 1978

In this section, we document the backgrounds about the Chinese economy since 1978, which would help to understand our theoretical framework and what we want to examine in this research.

The Enlarging Urban-Rural Income Inequality

The evolution of the urban-rural income inequality is shown in Figure 5.2, where we observe that the ratio of urban mean income and rural mean income almost doubled after 1978. Another important observation from Figure 5.2 is that the fluctuation of the urban-rural income inequality is quite similar to the movement of the overall Gini coefficient, which also verifies the conventional wisdom from decomposition analysis[4] that the enlarging urban-rural income inequality is one of the major determinants of the rising overall income inequality.

According to Wan and Zhang (2006) and Deng and Jefferson (2009), about 70% to 80% of the overall income inequality is attributed to the interregional income inequality. Therefore, understanding the factors that affect the urban-rural income inequality is very important for tackling the problem of overall income inequality in China.

***Hukou* and The Rural-to-Urban Migration Restriction**

The labor mobility barriers, which are mainly attributed to the *hukou* system and its associated regulations, not only distort the allocation of labor across regions, but also prevent rural children to receive education at urban areas, both of which contribute to the rising urban-rural income inequality.

It is not clear what are the impacts of simultaneously changing labor mobility barriers and reallocating government education spending on the urban-rural income inequality.

[4]For example, the decomposition analysis implemented by Zhu and Wan (2012), Lin et al. (2008), and Zhou and Qin (2012).

Although the potential impacts of changing labor mobility restrictions and education policies have been repeatedly emphasized (e.g., Zhu and Wan, 2012; Meng, 2012; Treiman, 2012; Wang et al., 2011; Wu et al., 2008; and Wu, 2011), without incorporating them into a unified framework, it is not easy to properly conduct further qualitative investigations.

The Urban-Biased Government Education Expenditure

Figure 5.1 demonstrates how biased is the government education expenditure in China. This urban-biased government education expenditure has been considered as an important determinant of the rising urban-rural income inequality (Wu, 2011; Treiman, 2012; Wang et al., 2011; Chen et al., 2010; and Zhu and Ma, 2009). In particular, Chen et al. (2010) demonstrated that if the government equally allocates the government education expenditures across regions from 1980 to 2001, the urban-rural income inequality in 2001 would by almost 50% lower. Figure 5.4 demonstrates that the public education expenditure does matter because it affects the average level of education in urban and rural areas[5].

The Difference of Urban-Rural Average Education Level

From Figure 5.4, we observe that the average education level in urban area is 3 to 5 years higher than that in the rural area. While the difference in urban-rural education has been widely considered as the factor affecting the increasing urban-rural income inequality in the empirical literature, Sicular et al. (2007) showed that the education gap accounts for more than 25% of the urban-rural income gap in 2002, the urban-rural income inequality would decline by 26%-30% if both regions have the same education level[6].

[5]Treiman (2012) even states that: "Arguably, educational differentials are at the root of virtually all forms of socioeconomic inequality."

[6]The findings of Sicular et al. (2007) are consistent with the argument that the most important determinant after age influencing an individual's education attainment is "place of residence", such as (Knight and Song, 1999), Knight et al. (2006), and Heckman and Yi (2012).

5.4 The Basic Framework of The Model

In this section, we describe the framework of our model. A standard discrete time growth model is extended with two sectors: a rural sector and an urban sector, where migration across regions is costly due to the presence of labor mobility restrictions. Within each region, there exist overlapping generations, and each generation lives for three periods. Individuals are heterogenous with respect to their innate learning ability, parental human capital level, and place of birth. We consider the interregional income inequality under two scenarios: segregation and integration.

Consumption and Preference

Following Ciriani (2007), Glomm and Ravikumar (1992), Munandar (2008), Takii and Tanaka (2009), and Chen et al. (2010), we assume that there is no population growth in our economy, and assume that a number of overlapping generations families exists in the economy. Each family consists of one child, one young adult, and one old adult. Each individual is endowed with *one* unit of time and lives for three periods. Children receive education to accumulate human capital and get supported by their parents. Young adults choose their labor supply and leisure, make decision about how to allocate their income on consumption, human capital investment of their children, and savings. Old adults live on their savings. As in Cengiz and Zhu (2012) and Munandar (2008), children are heterogeneous with respect to parental human capital h_{it} and innate learning ability θ_{it} within in each region j, where $j \in \{u, r\}$, u indicates urban region, while r represents rural region. We assume that all individuals can be identified by their *hukou* status: either urban or rural.

We assume that individuals have "Paternalistic" preferences[7] like Becker and Tomes (1979), Becker and Tomes (1986), Glomm and Ravikumar (1992), Takii and Tanaka (2009), and Cengiz and Zhu (2012), indicating that the young adults directly derive utility

[7]Three intergenerational preferences are commonly used: "Altruistic", "Paternalistic", and "Warm glow", see Lochner and Monge-Naranjo (2011) for detailed explanations.

from the human capital level h_{it+1} of their children. The utility function of the young adult at time t is specified as

$$u_{it} = u_{it}\left(c_{it}, c_{it+1}, l_{it}, h_{it+1}\right), \tag{5.1}$$

where l_{it} is the time spent on leisure, n_{it} is the time devoted to working, $n_{it} + l_{it} = 1$, and $u_{c_{it}} > 0$, $u_{c_{it}c_{it}} < 0$, $u_{c_{it+1}} > 0$, $u_{c_{it+1}c_{it+1}} < 0$, $u_{l_{it}} > 0$, $u_{l_{it}l_{it}} < 0$, $u_{h_{it+1}} > 0$, $u_{h_{it+1}h_{it+1}} < 0$. Moreover, the Inada conditions $\lim_{c_{it}\to\infty} u_{c_{it}} = 0$, $\lim_{c_{it}\to 0} u_{c_{it}} = \infty$, $\lim_{c_{it+1}\to\infty} u_{c_{it+1}} = 0$, $\lim_{c_{it+1}\to 0} u_{c_{it+1}} = \infty$, $\lim_{l_{it}\to\infty} u_{l_{it}} = 0$, $\lim_{l_{it}\to 0} u_{l_{it}} = \infty$, $\lim_{h_{it+1}\to\infty} u_{h_{it+1}} = 0$, $\lim_{h_{it+1}\to 0} u_{h_{it+1}} = \infty$ hold. We assume that all individuals share the same preference irrespective of their residential place. As in Ciriani (2007) and Cengiz and Zhu (2012), young adult i's utility function is specified as

$$u_{it}\left(c_{it}, c_{it+1}, l_{it}, h_{it+1}\right) = \log c_{it} + \beta \log c_{it+1} + \gamma \log l_{it} + \eta \log h_{it+1}, \tag{5.2}$$

where the discount factor $\beta \in (0, 1)$, the impact of leisure on utility $\gamma \in (0, 1)$, the "Paternalistic" degree of parents $\eta \in (0, 1)$.

Production and Technology

As in Hayashi and Prescott (2008), Esteban-Pretel and Sawada (2009), and Fu (2013), the economy consists of two regions: urban area and rural area in our model. We assume that there exists a comprehensive sector in each area, following Gang and Guang (2010) and Dollar and Jones (2012). The distribution of parental human capital is assumed to be log normal with density function $\phi_j\left(h_{it}\right)$, where $j \in \{u, r\}$[8]. The aggregate population at time t consists of rural people and urban people, $N_t = N_{rt} + N_{ut}$. The final output Y_t is composed of rural output and urban output, $Y_t = Y_{rt} + Y_{ut}$, and the price of final good is normalized to be 1.

[8]Consistent with the stylized facts, the initial human capital distribution of urban area is assumed to have a higher mean than that of rural area, but their evolutions are endogenously determined within the model.

In each region, the production function is specified as in Dollar and Jones (2012):

$$Y_{jt} = A_{jt}^{1-\alpha_j} K_{jt}^{\alpha_j} L_{jt}^{1-\alpha_j}, \tag{5.3}$$

where A_{jt} is the total factor productivity (TFP) in region j, which evolves as $A_{jt+1} = (1+\vartheta_j) A_{jt}$, where ϑ_j is the growth rate of regional TFP. K_{jt} is the capital input and evolves following $K_{jt+1} = \int_0^\infty s_{it} \phi_j(h_{it}) dh_{it}$. L_{jt} is the total effective labor employed and is defined as $L_{jt} = N_{jt} \int_0^\infty n_{it} h_{it} \phi_j(h_{it}) dh_{it}$. Profit maximization implies that r_{jt} equals the marginal product of capital and that w_{jt} equals the marginal product of labor

$$r_{jt} = \alpha_j k_{jt}^{\alpha_j - 1}, \tag{5.4}$$

$$w_{jt} = (1-\alpha_j) A_{jt} k_{jt}^{\alpha_j}, \tag{5.5}$$

where $k_{jt} = \frac{K_{jt}}{A_{jt} L_{jt}}$ indicates the physical capital per effective labor in region j.

Human Capital Accumulation

We assume that both individual education expenditure e_{it} and government education expenditure g_{jt} affect the human capital production, as in Cengiz and Zhu (2012), Chen et al. (2010), and Zhang (2005), so as to investigate how government education expenditure affects interregional income inequality via influencing the regional human capital level. The production function for children's human capital is[9]

$$h_{jit+1} = \theta_{it} e_{it}^{\varphi_1} g_{jt}^{\varphi_2} h_{jit}^{\varphi_3} H_{jt}^{1-\varphi_1-\varphi_2-\varphi_3}, \tag{5.6}$$

[9] This human capital production function captures three characters of the parental human capital. First, the direct impact of home coaching. Second, the spillover impact from local mean human capital as in Benabou (1996). Third, the indirect impact through affecting individual education spending e_{it}.

where $\ln h_{jit} \sim N\left(\mu_{h_{jt}}, \sigma^2_{\theta_{jt}}\right)$, $H_{jt} = \exp\left(\mu_{h_{jt}} + \frac{1}{2}\sigma^2_{h_{jt}}\right)$. The distribution of innate ability θ_{jit} is $\ln\theta_{jit} \sim N\left(\mu_{\theta_j}, \sigma^2_{\theta_j}\right)$, and it is stationary over time, so the mean learning ability is $\mathrm{E}\left(\theta_{jit}\right) = \exp\left(\mu_{\theta_j} + \frac{1}{2}\sigma^2_{\theta_j}\right)$.

Migration Cost

There exists labor mobility restrictions across regions, and migration is costly for individuals. However, individuals with higher human capital level are relatively easier to migrate as they can get urban jobs with higher probabilities and can adopt to new environments easily. Modifying the specification of Fu (2013), the migration cost function m_{it} is[10]

$$m_{it} \quad = \quad b\tilde{w}_{ut}h_{it}^{-1}, \tag{5.7}$$

where $\tilde{w}_{ut}$ is the urban wage rate per effective labor after migration is allowed. b is a policy parameter: $b = 0$ meaning no migration barrier; $b = \infty$ indicating that migration is strictly restricted.

Government Sector

Government finances its spending R_t through proportional labor income tax with rate τ_t: $\tau_t w_{rt} L_{rt} + \tau_t w_{ut} L_{ut} = R_t$. Balanced government budget requires

$$R_t = G_t + X_t, \tag{5.8}$$

where $G_t = N_{rt}g_{rt} + N_{ut}g_{ut}$, and it indicates the government education spending. X_t is the government non-education spending. The urban-biased education expenditure implies that $g_{ut} > g_{rt}$.

[10]A more general form of migration cost can be specified as $m_{it} = bF\left(h_{it}\right)$, where $F'\left(h_{it}\right) < 0$, like Fu (2013). I employ this tractable form to analytically characterize the critical level of human capital $\bar{h}_{rit}$.

5.5 Reallocating Education Spending and Inequality Under Segregation

In this section, we first characterize the equilibrium, and then examine the changes of government education spending policies on interregional income inequalities under prohibited migration across regions.

Competitive Equilibrium Under Segregation

To close the model under segregation, we characterize the competitive equilibrium that we are interested in when migration is strictly prohibited.

Definition 1. Given regional government education expenditure, tax rate, initial human capital and its distribution, initial physical capital, a competitive equilibrium is a set of prices $\{w_{jt}, r_{jt}\}_{t=0}^{t=\infty}$, for $j \in \{u,r\}$, and a sequence of quantities $\{c_{it}, c_{it+1}, n_{it}, l_{it}, s_{it}, e_{it}, K_{jt}, L_{jt}\}_{t=0}^{t=\infty}$, for $j \in \{u,r\}$, such that: (a) Agents optimization: young adults maximize their utility, firms maximize their profits; (b) Government keeps a balanced budget; (c) All markets clear.

Under competitive equilibrium, the optimal choices of the young adults are summarized by the following Lemma 1.

Lemma 1. *Under segregation, young adults optimally allocate their time indicates* $n_{it} = \frac{1+\beta+\eta\varphi_1}{1+\beta+\eta\varphi_1+\gamma}$ *and* $l_{it} = \frac{\gamma}{1+\beta+\eta\varphi_1+\gamma}$. *For given* τ_t *and* w_{jt}, *their optimal behavior implies* $c_{it} = \frac{(1-\tau_t)w_{jt}h_{it}}{1+\beta+\eta\varphi_1+\gamma}$, $c_{it+1} = \frac{\beta(1+r_{t+1})(1-\tau_t)w_{jt}h_{it}}{1+\beta+\eta\varphi_1+\gamma}$, $s_{it} = \frac{\beta(1-\tau_t)w_{jt}h_{it}}{1+\beta+\eta\varphi_1+\gamma}$, *and* $e_{it} = \frac{\eta\varphi_1(1-\tau_t)w_{jt}h_{it}}{1+\beta+\eta\varphi_1+\gamma}$.

The derivation of Lemma 1 is reported in Appendix. Employing Lemma 1, the human capital production function (5.6), and the formulas of individual income, the distribution of the next generation's income $\ln\pi_{jit+1} \sim N\left(\mu_{\pi_{jt+1}}, \sigma^2_{\pi_{jt+1}}\right)$ is characterized as

$$\begin{aligned}\mu_{\pi_{jt+1}} \quad &= \quad \ln\Theta_2 (1-\tau_t)^{\varphi_1} A_{jt}^{\varphi_1} k_{jt}^{\alpha_j\varphi_1} g_{jt}^{\varphi_2} A_{jt+1} k_{jt+1}^{\alpha_j} + \mu_{\theta_j} \\ &\quad + (1-\varphi_2)\mu_{h_{jt}} + \frac{1}{2}(1-\varphi_1-\varphi_2-\varphi_3)\sigma^2_{h_{jt}}, \qquad (5.9)\end{aligned}$$

$$\sigma^2_{\pi_{jt+1}} = \sigma^2_{\theta_{it}} + (\varphi_1 + \varphi_3)^2 \sigma^2_{h_{jt}}, \tag{5.10}$$

where $\Theta_1 \equiv \left[\frac{(1-\alpha_j)\eta\varphi_1}{1+\beta+\eta\varphi_1+\gamma}\right]^{\varphi_1}$, and $\Theta_2 \equiv (1+\beta+\eta\varphi_1)(\eta\varphi_1)^{\varphi_1}\left(\frac{1-\alpha_j}{1+\beta+\eta\varphi_1+\gamma}\right)^{1+\varphi_1}$. On the equilibrium path, the average of the log income within each region is given by $\mathrm{E}\left(\ln\pi_{jit+1}\right) = \mu_{\pi_{jt+1}}$. Equation (5.9) demonstrates that regional average log income $\mu_{\pi_{jt+1}}$ is positively correlated with government education expenditure g_{jt}. The following proposition 1 describes the impacts of reallocating government education spending on intraregional and interregional income inequalities under segregation.

Proposition 1. *For given government education resources, the policy of equally reallocating the government education expenditures tends to increase (decrease) the rural (urban) mean income, and thus reduce urban-rural income inequality. In addition, this reallocation does not cause intraregional income inequality to increase.*

Proposition 1 demonstrates that reallocating government education spending more equally would mitigate the interregional income inequality since it reduces the urban mean income and raises the rural mean income simultaneously, while the urban-rural income inequality is measured by the ratio of urban mean income to rural mean income. However, as the intraregional income inequality is affected by the variance of innate learning ability and that of parental human capital, reallocating government education resources doesn't affect the within regional income inequality.

Employing Lemma 1, the production function (5.3), the law of motion for local physical capital $K_{jt+1}$and local human capital H_{jt+1}, as well as the growth rates of physical capital and human capital, the economy on the equilibrium path under restricted rural-urban migration are characterized in the following Lemma 2.

Lemma 2. *Under segregation, on the equilibrium path, the growth rate of local physical capital $g_{K_{jt}}$ is characterized by $ln\left(1+g_{K_{jt}}\right) = \Lambda_1 - \left(1-\alpha_j\right) lnk_{jt}$. The growth rate of local human capital $g_{H_{jt}}$ is characterized by $ln\left(1+g_{H_{jt}}\right) = ln\Theta_1(1-\tau_t)^{\varphi_1} + lnA^{\varphi_1}_{jt} + lnk^{\alpha_j\varphi_1}_{jt} + lng^{\varphi_2}_{jt} + lnE\left(\theta_{jit}\right) - \varphi_2\mu_{h_{jt}} - \frac{1}{2}\left[(\varphi_1+\varphi_2+\varphi_3) - (\varphi_1+\varphi_3)^2\right]\sigma^2_{h_{jt}}$.*

The growth rate of local output $g_{Y_{jt}}$ *is indicated by* $ln\left(1+g_{Y_{jt}}\right)=\left(1-\alpha_j\right)\left(1+\vartheta_j\right)+\alpha_j ln\left(1+g_{K_{jt}}\right)+\left(1-\alpha_j\right)ln\left(1+g_{H_{jt}}\right)$.

In Lemma 2, $\Lambda_1=\ln\Theta_4$, $\Theta_4\equiv\frac{\beta N_j^{-1}(1-\tau_t)(1-\alpha_j)}{1+\beta+\eta\varphi_1}$, $\Theta_1\equiv\left[\frac{(1-\alpha_j)\eta\varphi_1}{1+\beta+\eta\varphi_1+\gamma}\right]^{\varphi_1}$, and $\mathrm{E}\left(\theta_{jit}\right)=\exp\left(\mu_{\theta_j}+\frac{1}{2}\sigma^2_{\theta_j}\right)$. As $(\varphi_1+\varphi_2+\varphi_3)-(\varphi_1+\varphi_3)^2>0$, Lemma 2 implies that on the equilibrium path, the higher the intraregional income inequality $\sigma^2_{h_{jt}}$, the lower the growth rate of local output $g_{Y_{jt}}$. In addition, the government education expenditure per student g_{jt} is positively correlated with the local output growth rate $g_{Y_{jt}}$. When the economy reaches its steady state as time goes to infinity, the physical capital per effective labor, regional mean human capital, and regional mean income are summarized in the following Lemma 3.

Lemma 3. *For region j under segregation, the steady state physical capital per effective labor is* $lnk_{j\infty}=\frac{1}{\alpha_j\varphi_1+1-\alpha_j}\left\{\Lambda_1-ln\Theta_1\left(1-\tau_\infty\right)^{\varphi_1}-\varphi_1 lnA_{j\infty}-\varphi_2 lng_{j\infty}-lnE\left(\theta_{ji\infty}\right)+\varphi_2\mu_{h_{j\infty}}+\frac{1}{2}\left[(\varphi_1+\varphi_2+\varphi_3)-(\varphi_1+\varphi_3)^2\right]\sigma^2_{h_{j\infty}}\right\}$. *The mean human capital is indicated by* $\mu_{h_{j\infty}}=\frac{1}{\varphi_2}\left\{ln\Theta_1\left(1-\tau_\infty\right)^{\varphi_1}+\varphi_1 lnA_{j\infty}+\alpha_j\varphi_1 lnk_{j\infty}+\varphi_2 lng_{j\infty}+\mu_{\theta_j}+\frac{1}{2}\left(1-\varphi_1-\varphi_2-\varphi_3\right)\right\}$. *The Average income is implied by* $\mu_{\pi_{j\infty}}=ln\Theta_2\left(1-\tau_\infty\right)^{\varphi_1}+\left(1+\varphi_1\right)lnA_{j\infty}+\left[\alpha_j(1+\varphi_1)\right]lnk_{j\infty}+\varphi_2 lng_{j\infty}+\mu_{\theta_j}+\left(1-\varphi_2\right)\mu_{h_{j\infty}}+\frac{1}{2}\left(1-\varphi_1-\varphi_2-\varphi_3\right)\sigma^2_{h_{j\infty}}$. *The intraregional income inequality is* $\sigma^2_{\pi_{j\infty}}=\frac{\sigma^2_{\theta_j}}{1-(\varphi_1+\varphi_3)^2}$.

In Lemma 3, $\Theta_2\equiv\left(1+\beta+\eta\varphi_1\right)\left(\eta\varphi_1\right)^{\varphi_1}\left(\frac{1-\alpha_j}{1+\beta+\eta\varphi_1+\gamma}\right)^{1+\varphi_1}$, $\Lambda_1=\ln\Theta_4$, and $\Theta_4\equiv\frac{\beta N_j^{-1}(1-\tau_t)(1-\alpha_j)}{1+\beta+\eta\varphi_1}$. Lemma 3 implies that in the steady state as well as on the equilibrium path, under restricted rural-urban migration, increasing (decreasing) the government education expenditure per rural (urban) student tends to shrink the urban-rural income inequality. However, reallocating government education expenditure more equally doesn't affect the intraregional income inequality as it is only determined by innate learning ability. Now let's examine what would be the the effects of reallocating government education spending, reducing labor mobility barriers, as well as their interaction on interregional income inequality when migration restrictions are relaxed.

5.6 Reallocating Education Spending and Inequality Under Integration

In this section, we first describe the equilibrium under relaxed migration, and then examine the effects of reallocating government education expenditures, relaxing labor mobility restrictions, and their interaction on interregional income inequality.

The Critical Rural Human Capital Level

The rural young adults make their migration decisions by comparing the net income of working in the urban sector and that of staying in the rural sector, i.e., $\tilde{w}_{ut} n_{it} h_{rit} - m_{it} \geq \tilde{w}_{rt} n_{it} h_{rit}$, where $\tilde{w}_{jt}$ is the wage rate in region j when migration is allowed. Combining with (5.7), the rural critical human capital level h^c_{rt} is

$$h^c_{rt} \geq \sqrt{\frac{b\tilde{w}_{ut}}{n_{it}\left(\tilde{w}_{ut} - \tilde{w}_{rt}\right)}} \tag{5.11}$$

Young adults whose human capital are above h^c_{rt} can work in the urban region, but they are still counted as rural people and their children are considered as rural children.

Under relaxed migration, the rural effective labor and urban effective labor are $\tilde{L}_{rt} = N_{rt}\int_0^{h^c_{rit}} n_{it} h_{it} \phi_r\left(h_{it}\right) dh_{it}$ and $\tilde{L}_{ut} = N_{ut}\int_0^{\infty} n_{it} h_{it} \phi_u\left(h_{it}\right) dh_{it} + N_{rt}\int_{h^c_{rit}}^{\infty} n_{it} h_{it} \phi_r\left(h_{it}\right) dh_{it}$, respectively. Profit maximization of firm delivers the new wage rate and interest under rural-urban migration restriction

$$\tilde{w}_{jt} = \left(1-\alpha_j\right) A_{jt} \tilde{k}^{\alpha_j}_{jt} \tag{5.12}$$

where $\tilde{k}_{jt} = \frac{\tilde{K}_{jt}}{A_{jt}\tilde{L}_{jt}}$ indicates the physical capital per effective labor in region j. Equation (5.12) shows that the urban (rural) wage rate is a decreasing (increasing) function of total urban (rural) effective labor.

Competitive Equilibrium Under Integration

To give an overview picture of the economy under integration, we characterize the competitive equilibrium that we are interested in when migration is allowed.

Definition 2. For given government education expenditure, tax rate, initial human capital and its distribution, initial physical capital, the competitive equilibrium under relaxed migration is a pair of prices $\left\{\tilde{w}_{jt}, r_{jt}\right\}_{t=0}^{t=\infty}$, for $j \in \{u,r\}$, a set of quantities $\left\{c_{it}, n_{it}, l_{it}, s_{it}, e_{it}, \tilde{K}_{jt}, \tilde{L}_{jt}\right\}_{t=0}^{t=\infty}$, for $j \in \{u,r\}$, such that: (a) Agents optimization: both migrating and non-migrating young adults maximize utility, firms maximize profits; (b) Government keeps a balanced budget; (c) There is no more voluntary migration occurs in equilibrium; (d) All markets clear.

Under integration, there are three categories of young adults in the economy: the rural migrants, the rural stayers, and the urban residents. The following Lemma 4 summarizes the optimization results of rural stayers and urban residents.

Lemma 4. *For rural stayers and urban residents, the allocation of time for young adults is* $n_{it} = \frac{1+\beta+\eta\varphi_1}{1+\beta+\eta\varphi_1+\gamma}$ *and* $l_{it} = \frac{\gamma}{1+\beta+\eta\varphi_1+\gamma}$. *For given* τ_t *and* $\tilde{w}_{jt}$, *their optimization requires* $c_{it} = \frac{(1-\tau_t)\tilde{w}_{jt}h_{it}}{1+\beta+\eta\varphi_1+\gamma}$, $c_{it+1} = \frac{\beta(1+r_{t+1})(1-\tau_t)\tilde{w}_{jt}h_{it}}{1+\beta+\eta\varphi_1+\gamma}$, $s_{it} = \frac{\beta(1-\tau_t)\tilde{w}_{jt}h_{it}}{1+\beta+\eta\varphi_1+\gamma}$, *and* $e_{it} = \frac{\eta\varphi_1(1-\tau_t)\tilde{w}_{jt}h_{it}}{1+\beta+\eta\varphi_1+\gamma}$.

When migration is allowed, the income distribution of rural stayers and that of the rural migrants are no longer log normal. It is very difficult to obtain any analytical results about the rural mean income without imposing any additional assumptions. To analytically characterize the mean of log income within the rural and urban area, we approximate the income distribution of rural stayers and rural migrants by the log normal distribution[11].

With the log normal income distribution of rural stayers and rural migrants, Lemma 4, the human capital production function (5.6), and wage rate (5.12) together imply that the mean income of rural migrants and that of urban residents are

[11] We realize that this is a fairly strong assumption in the long run, but at least in the short run, say within two to three generations, the log normal distribution is a reasonable approximation.

$$\mu^s_{\tilde{\pi}_{rt+1}} = \ln\Theta_2 (1-\tau_t)^{\varphi_1} A_{rt}^{\varphi_1} \tilde{k}_{rt}^{\alpha_j \varphi_1} g_{rt}^{\varphi_2} A_{rt+1} \tilde{k}_{rt+1}^{\alpha_j} + \mu_{\theta_r} + (1-\varphi_2)\mu_{h_{rt}} + \varphi_4 \frac{1}{2}\sigma^2_{h_{rt}}, \tag{5.13}$$

$$\mu_{\tilde{\pi}_{ut+1}} = \ln\Theta_2 (1-\tau_t)^{\varphi_1} A_{ut}^{\varphi_1} \tilde{k}_{ut}^{\alpha_j \varphi_1} g_{ut}^{\varphi_2} A_{ut+1} \tilde{k}_{ut+1}^{\alpha_j} + \mu_{\theta_u} + (1-\varphi_2)\mu_{h_{ut}} + \frac{1}{2}\varphi_4 \sigma^2_{h_{ut}}. \tag{5.14}$$

where $\Theta_2 \equiv (1+\beta+\eta\varphi_1)(\eta\varphi_1)^{\varphi_1}\left(\frac{1-\alpha_j}{1+\beta+\eta\varphi_1+\gamma}\right)^{1+\varphi_1}$, and $\varphi_4 = 1-\varphi_1-\varphi_2-\varphi_3$. Equation (5.13) and equation (5.14) clearly demonstrate that urban-biased government education expenditure tends to increase (decrease) the urban (rural) mean income at time $t+1$ even if the young adults receive the same wage rate at time t, the urban-rural income inequality persists due to this urban-biased policy. Meanwhile, the rural migrants optimal decisions are summarized by the following Lemma 5.

Lemma 5. *For rural migrants, the allocation of time for young adults is* $n_{it} = \frac{(1+\beta+\eta\varphi_1)(1-\tau_t)+\gamma b h_{it}^{-2}}{(1+\beta+\eta\varphi_1+\gamma)(1-\tau_t)}$ *and* $l_{it} = \frac{\gamma\left(1-\tau_t-bh_{it}^{-2}\right)}{(1+\beta+\eta\varphi_1+\gamma)(1-\tau_t)}$. *For given* τ_t *and* $\tilde{w}_{jt}$, *their optimization requires* $c_{it} = \frac{\left(1-\tau_t-bh_{it}^{-2}\right)\tilde{w}_{ut}h_{it}}{1+\beta+\eta\varphi_1+\gamma}$, $c_{it+1} = \frac{\beta(1+r_{t+1})\left(1-\tau_t-bh_{it}^{-2}\right)\tilde{w}_{ut}h_{it}}{1+\beta+\eta\varphi_1+\gamma}$, $s_{it} = \frac{\beta\left(1-\tau_t-bh_{it}^{-2}\right)\tilde{w}_{ut}h_{it}}{1+\beta+\eta\varphi_1+\gamma}$, *and* $e_{it} = \frac{\eta\varphi_1\left(1-\tau_t-bh_{it}^{-2}\right)\tilde{w}_{ut}h_{it}}{1+\beta+\eta\varphi_1+\gamma}$.

In Lemma 5, $j \in \{u,r\}$. Lemma 5 shows that the optimal allocation of time depends on individual human capital level for the rural migrants, this is different from what we observe from Lemma 3 and Lemma 4, one explanation is that high human capital individuals are more productive such that they can spend less time on working. Combining Lemma 5, the human capital formation function (5.6), and wage rate (5.12), the mean income of rural migrants can be characterized by

$$\mu^m_{\tilde{\pi}_{rt+1}} = \ln\Theta_6 + \mathrm{E}\left[\ln\frac{(1+\beta+\eta\varphi_1)(1-\tau_t)+\gamma b h_{it}^{-2}}{(1-\tau_t)}\right] + \mathrm{E}\left\{\ln\left[\left(1-\tau_t-bh_{it}^{-2}\right)\right]^{\varphi_1}\right\} + \mathrm{E}\left[\ln\left((1-\alpha_u)A_{ut}\tilde{k}_{ut}^{\alpha_u}h_{it}\right)^{\varphi_1}\right] + \ln g_{rt}^{\varphi_2}(1-\alpha_u)A_{ut+1}\tilde{k}_{ut+1}^{\alpha_u} + \mu_{\theta_j} + \varphi_3\mu_{h_{jt}}$$

$$+(1-\varphi_1-\varphi_2-\varphi_3)\left(\mu_{h_{jt}}+\frac{1}{2}\sigma^2_{h_{jt}}\right) \tag{5.15}$$

where $\Theta_6 \equiv \frac{(\eta\varphi_1)^{\varphi_1}}{(1+\beta+\eta\varphi_1+\gamma)^{1+\varphi_1}}$. Equation (5.15) shows that the impact of reducing labor mobility barriers on the mean income of rural migrants is ambiguous since it decreases the income by spending more on consumption and increases the income by supplying more labor, the overall impact on mean income could be either positive or negative.

Discussions About The Impacts of Different Government Intervention Policies

According to equation (5.11), $\frac{\partial h^c_{rit}}{\partial b} > 0$, reducing the labor mobility barriers tends to decrease the rural threshold human capital level, above which individuals would migrate to urban area. Compared with not reducing the migration barriers, more rural people whose human capital is above h^c_{rit} would choose to work in the urban area. This enlarging migration reduces the total working effective labor in the rural area, equation (5.5) implies that the wage rate $\tilde{w}_{rt}$ of the rural stayers would increase, and so would the mean income of the urban stayers.

Meanwhile, as reducing b increases the total working effective labor in the urban area, equation (5.5) implies that the wage rate $\tilde{w}_{ut}$ of the urban residents and rural migrants would decrease, hence, reducing b would decrease the mean income of the rural migrants. Removing the labor mobility barrier generates a positive effect on the mean income of rural non-migrants, and a negative effect on the mean income of rural migrants, so qualitatively it is not clear whether removing labor mobility barriers increase or reduce the aggregate rural mean income. Hence, the qualitative impacts of removing the labor mobility restrictions on interregional income inequality could be positive or negative.

Our comparative dynamics analysis demonstrate that removing labor mobility restrictions has positive effect on the mean income for rural stayers, but negative effect on the average income for rural migrants. However, increasing rural education expenditure per student would raise the aggregate rural mean income, which would mitigate the negative effects on the mean income of rural migrants caused by removing labor mobility restrictions. Moreover, for the urban people, simultaneously changing the labor mobility restrictions and reallocating education spending would reduce their mean income. Therefore, the policy combination of simultaneously reallocating government spending and removing labor mobility restrictions would be more likely to reduce the income inequality across regions.

Therefore, simply removing labor mobility barrier doesn't necessarily reduce the urban-rural income inequality due to its counteracting impacts on the mean incomes of rural migrants and rural stayers. But reallocating government education spending more equally would always mitigate the interregional income inequality since it reduces the urban mean income and raises the rural mean income simultaneously, while the urban-rural income inequality is measured by the ratio of urban mean income to rural mean income. The policy combination of simultaneously removing labor mobility barriers and redistributing government expenditures more equally is more likely to mitigate the rising interregional income inequality, if the impact from reallocating government expenditures dominates.

5.7 Conclusion

The enlarging urban-rural income inequality during China's rapid growth process has been concerned by many economists and policy makers, the existence of labor mobility barriers and the urban-biased government education spending policies have been considered as two of the main factors affecting the rising income inequality across regions.

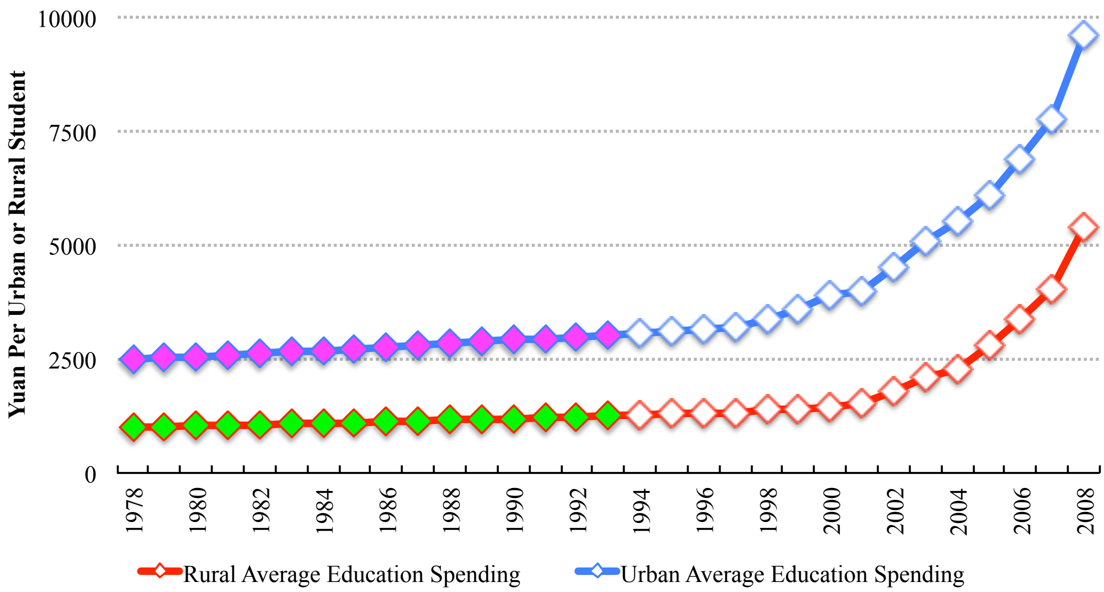
To investigate how government education spending and labor mobility barriers affect the enlarging urban-rural income inequality, we develop an analytical two-region growth model with heterogenous individuals, where the characters of our interested policies are introduced: labor mobility barriers affects the cost of migration across regions, while the government education spending influences the accumulation of individual human capital. Through imposing some tractability specifications about the distribution of innate learning abilities and the distribution of parental human capital level, we characterize the regional mean income via aggregation. The interregional income inequality is measured by the ratio of urban mean income to rural mean income, since both the numerator and the denominator are affected by the parameters capturing the effect of labor mobility barriers and the exogenous variables of government education spending, we could evaluate the impacts of changing labor mobility barriers and reallocating government education spending on the interregional income inequality through comparative dynamics analysis.

Several interesting qualitative results are obtained in our comparative dynamic analysis. First, reallocating government education spending more equally would always mitigate the interregional income inequality, which is measured by the ratio of urban mean income to rural mean income, since this reallocation reduces the urban mean income and raises the rural mean income simultaneously. Second, only reducing the labor mobility barriers does not necessarily decrease the urban-rural income inequality, because it generates counteracting effects on the mean income of the rural stayers and that of the rural migrants. Third, the policy combination of simultaneously reducing the labor mobility barriers and reallocating the government education resources equally is more likely to mitigate the rising interregional income inequality. Our analysis suggests that if government wants to effectively alleviate the problem of enlarging urban-rural income inequality in China, only removing the labor mobility restrictions across regions is not enough, while reallocating government education spending more equally across regions is a very important policy candidate. Our analysis in this paper has very strong policy implications concerning what the Chinese government is doing now, i.e., they gradually erases the difference between urban *hukou* and rural *hukou*, as the single policy instrument of removing labor mobility barrier which is not enough to mitigate the enlarging interregional income inequality, and thus the reallocation of government education resources should also be considered.

In this paper, we only conduct qualitative analysis through employing comparative dynamics analysis, which is the main drawback of our study. Further quantitative analysis could be conducted for future research.

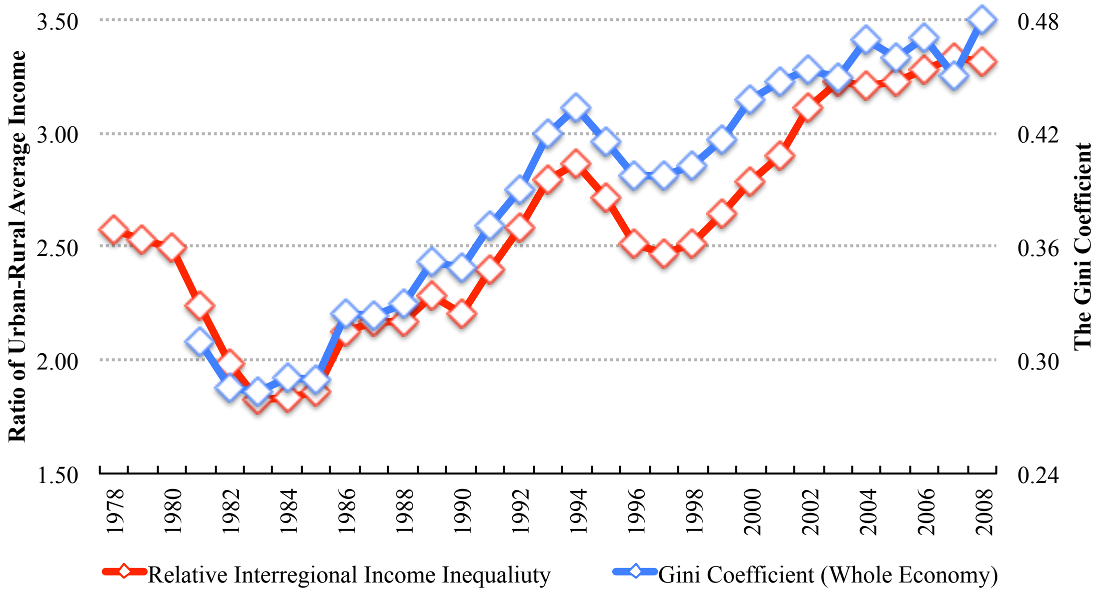
5.A Main Figures

Figure 5.1: The Education Expenditure Per Student: Urban-Rural Comparison



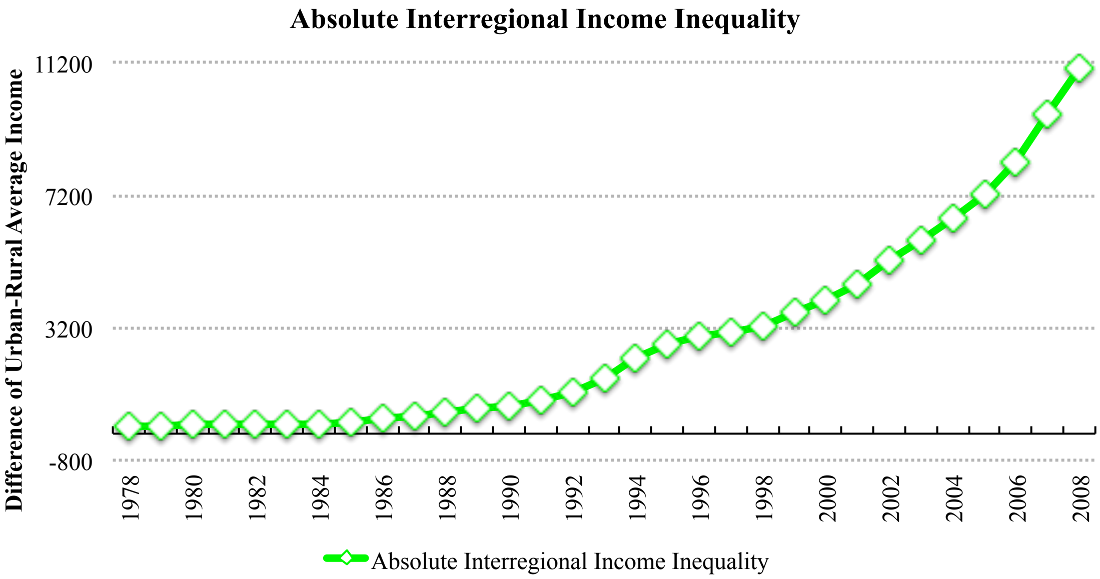
Notes: (1) For 1996-2008, the data is computed following the method of Chen et al. (2010) using the source data from China Educational Expenses Statistical Yearbook and China Statistical Yearbook, China Statistics Press, Various Years; (2) For the data from 1984 to 1993, we extrapolate the government education expenditure per urban (rural) students by assuming that the number of urban (rural) students is proportional to urban (rural) population and the growth rate of government education expenditure in the urban (rural) area is constant during this period.

Figure 5.2: The Urban-Rural Income Inequality from 1978 to 2008: Relative Measure



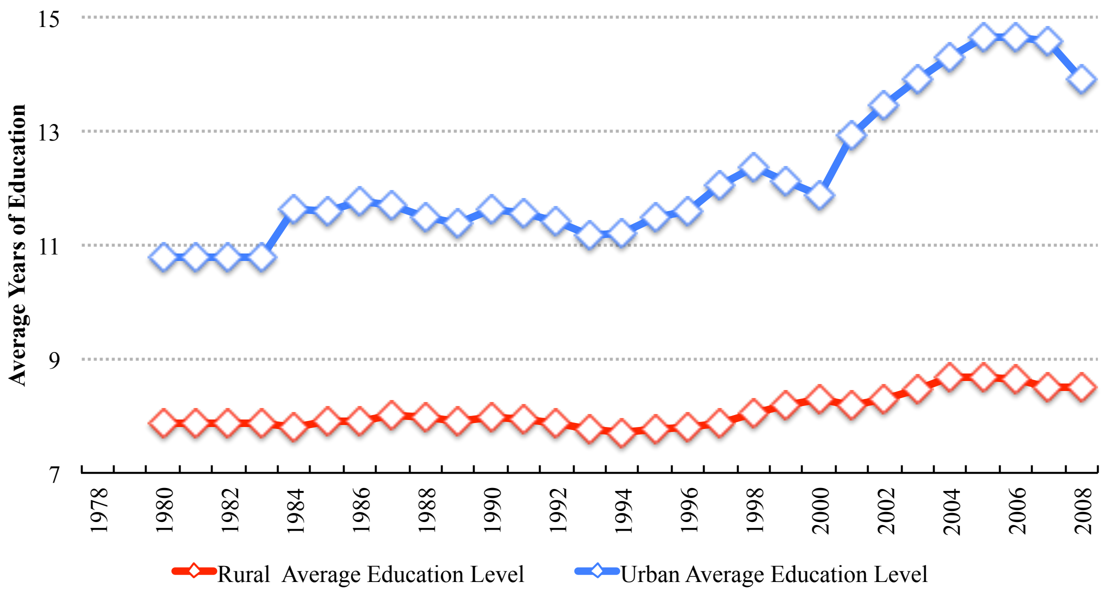
Notes: (1) The relative urban-rural income inequality measure is computed using the source data from China Compendium of Statistics:1949-2008. (2) The Gini Coefficient is from Bureau of Statistics in China.

Figure 5.3: The Urban-Rural Income Inequality from 1978 to 2008: Absolute Measure



Notes: The absolute urban-rural income inequality measure is computed using the source data from China Compendium of Statistics:1949-2008.

Figure 5.4: The Average Years of Education in China: Urban-Rural Comparison



Note: The data here is from China Center for Human Capital and Labor Market Research at Central University of Finance and Economics in China.

5.B Data Source and Description

The definition and sources of data employed in this paper are described in this section. Some adjustments are made to the original data, which are also explained here.

The Aggregate and Regional GDPs: (1) The nominal national gross domestic product (GDP) is from China Compendium of Statistics:1949-2008. (2) The nominal rural GDP: 1978-1992 is from China Rural Statistical Yearbook: 1985-1993; 1993-2008 is from the Analysis and Forecasts of China's Rural Economy (Green Book of Rural Area, By China Academy of Social Sciences and National Bureau of Statistics), 1992-2011. (3) The nominal urban GDP is computed by the author by deducting nominal rural GDP from the aggregate GDP. All those nominal variables are adjusted using the household consumption index (1985 Base Year) from China Compendium of Statistics:1949-2008 to get real terms.

The Working Population: national total number of employed persons, urban number of employed persons, rural number of employed persons are adopted from China Compendium of Statistics:1949-2008.

The Human Capital (Years of Education): national average human capital , rural average human capital, urban average human capital are calculated based on the sources data from China Center for Human Capital and Labor Market Research, calculation is implemented by modifying the method of Wang and Yao (1999). Urban total effective labor, rural total effective labor are computed by multiplying the average human capital and the working age population.

The Government Education Expenditure Per Student: For 1996-2008, the data is computed following the method of Chen et al. (2010) using the source data from China Educational Expenses Statistical Yearbook and China Statistical Yearbook, China Statistics Press, Various Years. For the data from 1984 to 1993, we extrapolate the government education expenditure per urban (rural) students by assuming that the number of urban (rural) students is proportional to urban (rural) population and the growth rate of government education expenditure in the urban (rural) area is constant during this period, our aggregated results are consistent with the aggregated results in Zhu and Ma (2009).

5.C Proof of Key Equations

Derivation of Lemma 1 The results of young adult's optimization problem, which is to maximize (5.2) subject to the consumption constraints $c_{it}+s_{it}+e_{it}=(1-\tau_t)w_{jt}n_{it}h_{it}$, $c_{it+1}=(1+r_{t+1})s_{it}$, the time constraint $n_{it}+l_{it}=1$, and human capital accumulation function (5.6). The Lagrangian for this problem is

$$\begin{aligned}\mathscr{L} &= \log c_{it}+\beta\log(1+r_{t+1})s_{it}+\gamma\log(1-n_{it})+\eta\log\theta_{it}e_{it}^{\varphi_1}g_{jt}^{\varphi_2}h_{it}^{\varphi_3}H_{jt}^{1-\varphi_1-\varphi_2-\varphi_3} \\ &\quad +\lambda_t\left[(1-\tau_t)w_{jt}n_{it}h_{it}-c_{it}-s_{it}-e_{it}\right] \qquad (5.C1)\end{aligned}$$

The First Order Conditions (FOCs) are:

$$\begin{aligned} c_{it}: \quad \frac{1}{c_{it}} &= \lambda_t & (5.C2)\\ s_{it}: \quad \beta\frac{1}{s_{it}} &= \lambda_t & (5.C3)\\ e_{it}: \quad \eta\varphi_1\frac{1}{e_{it}} &= \lambda_t & (5.C4)\\ n_{it}: \quad \gamma\frac{1}{1-n_{it}} &= \lambda_t(1-\tau_t)w_{jt}h_{it} & (5.C5)\\ \lambda_t: \quad c_{it}+s_{it}+e_{it} &= (1-\tau_t)w_{jt}n_{it}h_{it} & (5.C6)\end{aligned}$$

Solving these five equations (5.C2), (5.C3), (5.C4), (5.C5), and (5.C6) simultaneous delivers the optimal choices of the young adults in Lemma 1.

Proof of Lemma 2 Lemma 2 characterizes the equilibrium path of the economy under segregation. The local physical capital is $K_{jt+1}=\int_0^\infty s_{it}\phi_j(h_{it})\,dh_{it}$, with lemma 1 and equation (5.5), it can be written as $K_{jt+1}=\Theta_3 A_{jt}k_{jt}^{\alpha_j}\int_0^\infty h_{it}\phi_j(h_{it})\,dh_{it}$,

$\Theta_3 \equiv \frac{\beta(1-\tau_t)(1-\alpha_j)}{1+\beta+\eta\varphi_1+\gamma}$. As $H_{jt} = \int_0^\infty h_{it}\phi_j(h_{it})\,dh_{it}$, $K_{jt+1} = \Theta_3 A_{jt}^{1-\alpha_j} K_{jt}^{\alpha_j} L_{jt}^{-\alpha_j} H_{jt}$, thus $\frac{K_{jt+1}}{K_{jt}} = \Theta_3 A_{jt}^{1-\alpha_j} K_{jt}^{\alpha_j-1} L_{jt}^{-\alpha_j} H_{jt}$, plugging L_{jt} and Θ_3, and rearranging delivers $\frac{K_{jt+1}}{K_{jt}} = \frac{\beta N_j^{-1}(1-\tau_t)(1-\alpha_j)}{1+\beta+\eta\varphi_1} k_{jt}^{\alpha_j-1}$. Let $\Theta_4 \equiv \frac{\beta N_j^{-1}(1-\tau_t)(1-\alpha_j)}{1+\beta+\eta\varphi_1}$, we get $\ln\left(1+g_{K_{jt}}\right) = \Lambda_1 - \left(1-\alpha_j\right)\ln k_{jt}$, where $g_{K_{jt}} \equiv \frac{K_{jt+1}}{K_{jt}} - 1$.

As $H_{jt} = exp\left(\mu_{h_{jt}} + \frac{1}{2}\sigma^2_{h_{jt}}\right)$, $\frac{H_{jt+1}}{H_{jt}} = exp\left(\mu_{h_{jt+1}} - \mu_{h_{jt}} + \frac{1}{2}\sigma^2_{h_{jt+1}} - \frac{1}{2}\sigma^2_{h_{jt}}\right)$, define $g_{H_{jt}} \equiv \frac{H_{jt+1}}{H_{jt}} - 1$, thus $\ln\left(1+g_{H_{jt}}\right) = \mu_{h_{jt+1}} - \mu_{h_{jt}} + \frac{1}{2}\sigma^2_{h_{jt+1}} - \frac{1}{2}\sigma^2_{h_{jt}}$. Plugging equation of $\mu_{h_{jt+1}}$ and equation of $\sigma^2_{h_{jt+1}}$, rearranging and combining terms, we get $\ln\left(1+g_{H_{jt}}\right) = \ln\Theta_1\left(1-\tau_t\right)^{\varphi_1} + \ln A_{jt}^{\varphi_1} + \ln k_{jt}^{\alpha_j\varphi_1} + \ln g_{jt}^{\varphi_2} + \ln \mathrm{E}\left(\theta_{jit}\right) - \varphi_2\mu_{h_{jt}} - \frac{1}{2}\left[\left(\varphi_1+\varphi_2+\varphi_3\right) - \left(\varphi_1+\varphi_3\right)^2\right]\sigma^2_{h_{jt}}$, $\Theta_1 \equiv \left[\frac{(1-\alpha_j)\eta\varphi_1}{1+\beta+\eta\varphi_1+\gamma}\right]^{\varphi_1}$.

From the equation (5.3), we have $\frac{Y_{jt+1}}{Y_{jt}} = \left(\frac{A_{jt+1}}{A_{jt}}\right)^{1-\alpha_j}\left(\frac{K_{jt+1}}{K_{jt}}\right)^{\alpha_j}\left(\frac{H_{jt+1}}{H_{jt}}\right)^{1-\alpha_j}$, taking logs and employing the notations above, we can get the growth rate of local output under segregation.

Proof of Lemma 3 Lemma 3 describes the steady state of the economy under restricted migration. From Lemma 2 and the balanced growth path condition $g_{H_{j\infty}} = g_{K_{j\infty}}$, we get: $\Lambda_1 - \left(1-\alpha_j\right)\ln k_{j\infty} = \ln\Theta_1\left(1-\tau_\infty\right)^{\varphi_1} + \varphi_1 \ln A_{j\infty} + \alpha_j\varphi_1 \ln k_{j\infty} + \varphi_2 \ln g_{j\infty} + \ln \mathrm{E}\left(\theta_{jit}\right) - \varphi_2\mu_{h_{j\infty}} - \frac{1}{2}\left[\left(\varphi_1+\varphi_2+\varphi_3\right) - \left(\varphi_1+\varphi_3\right)^2\right]\sigma^2_{h_j}$, collecting common terms and rearrange, we get the steady state physical capital per effective labor.

From equation $\mu_{h_{jt+1}}$, imposing the steady state conditions delivers $\mu_{h_{j\infty}} = \ln\Theta_1\left(1-\tau_\infty\right)^{\varphi_1}\ A_{j\infty}^{\varphi_1} k_{j\infty}^{\alpha_j\varphi_1} g_{j\infty}^{\varphi_2} + \mu_{\theta_j} + \left(1-\varphi_2\right)\mu_{h_{j\infty}} + \frac{1}{2}\left(1-\varphi_1-\varphi_2-\varphi_3\right)\sigma^2_{h_{j\infty}}$, rearranging and simplifying would deliver $\varphi_2\mu_{h_{j\infty}} = \ln\Theta_1\left(1-\tau_\infty\right)^{\varphi_1} A_{j\infty}^{\varphi_1} k_{j\infty}^{\alpha_j\varphi_1} g_{j\infty}^{\varphi_2} + \mu_{\theta_j} + \frac{1}{2}\left(1-\varphi_1-\varphi_2-\varphi_3\right)\sigma^2_{h_{j\infty}}$.

Employing the equation of $\mu_{\pi_{jt+1}}$and the steady state conditions deliver $\mu_{\pi_{j\infty}} = \ln\Theta_2\left(1-\tau_\infty\right)^{\varphi_1} A_{j\infty}^{\varphi_1} k_{j\infty}^{\alpha_j\varphi_1} g_{j\infty}^{\varphi_2} A_{j\infty} k_{j\infty}^{\alpha_j} + \mu_{\theta_j} + \left(1-\varphi_2\right)\mu_{h_{j\infty}} + \frac{1}{2}\left(1-\varphi_1-\varphi_2-\varphi_3\right)\sigma^2_{h_{j\infty}}$, rearrange and we get: $\mu_{\pi_{j\infty}} = \ln\Theta_2\left(1-\tau_\infty\right)^{\varphi_1} + \left(1+\varphi_1\right)\ln A_{j\infty} + \left[\alpha_j(1+\varphi_1)\right]\ln k_{j\infty} + \varphi_2 \ln g_{j\infty} + \mu_{\theta_j} + \left(1-\varphi_2\right)\mu_{h_{j\infty}} + \frac{1}{2}\left(1-\varphi_1-\varphi_2\ -\varphi_3\right)\sigma^2_{h_{j\infty}}$.

Using the equation $\sigma^2_{\pi_{jt+1}}$ and imposing the steady state conditions, we get: $\sigma^2_{\pi_{j\infty}} =$

$\sigma^2_{\theta_{ji}} + (\varphi_1+\varphi_3)^2\,\sigma^2_{h_{j\infty}}$, simplifying the previous equation delivers the steady state within regional income inequality $\sigma^2_{\pi_{j\infty}} = \frac{\sigma^2_{\theta_j}}{1-(\varphi_1+\varphi_3)^2}$.

Proof of Lemma 4 Lemma 4 characterizes the solution to the rural stayer's problem under relaxed migration. Maximizing (5.2) subject to the consumption constraints $c_{it} + s_{it} + e_{it} = (1-\tau_t)\,\tilde{w}_{jt}n_{it}h_{it}$, $c_{it+1} = (1+r_{t+1})\,s_{it}$, the time constraint $n_{it}+l_{it} = 1$, and human capital accumulation function (5.6). The Lagrangian for this problem is

$$\begin{aligned}\mathscr{L} &= \log c_{it} + \beta\log(1+r_{t+1})\,s_{it} + \gamma\log(1-n_{it}) + \eta\log\theta_{it}e_{it}^{\varphi_1}g_{jt}^{\varphi_2}h_{it}^{\varphi_3}H_{jt}^{1-\varphi_1-\varphi_2-\varphi_3} \\ &\quad +\lambda_t\left[(1-\tau_t)\,\tilde{w}_{jt}n_{it}h_{it} - c_{it} - s_{it} - e_{it}\right] \qquad (5.C7)\end{aligned}$$

The First Order Conditions (FOCs) are:

$$\begin{aligned} c_{it}: &\quad \frac{1}{c_{it}} = \lambda_t &(5.C8)\\ s_{it}: &\quad \beta\frac{1}{s_{it}} = \lambda_t &(5.C9)\\ e_{it}: &\quad \eta\varphi_1\frac{1}{e_{it}} = \lambda_t &(5.C10)\\ n_{it}: &\quad \gamma\frac{1}{1-n_{it}} = \lambda_t(1-\tau_t)\,\tilde{w}_{jt}h_{it} &(5.C11)\\ \lambda_t: &\quad c_{it}+s_{it}+e_{it} = (1-\tau_t)\,\tilde{w}_{jt}n_{it}h_{it} &(5.C12)\end{aligned}$$

Solving these five equations (5.C8), (5.C9), (5.C10), (5.C11), and (5.C12) simultaneous delivers the main results in Lemma 4.

Proof of Lemma 5 Lemma 5 characterizes the optimal solution to the rural migrant's problem. Their problem is to maximize (5.2) subject to the consumption constraints $c_{it} + s_{it} + e_{it} = (1-\tau_t)\,\tilde{w}_{jt}n_{it}h_{it} - b\tilde{w}_{ut}h_{rit}^{-1}$, $c_{it+1} = (1+r_{t+1})\,s_{it}$, the time constraint $n_{it}+l_{it} = 1$, and human capital accumulation function (5.6). The Lagrangian for this problem is

$$
\begin{aligned}
\mathscr{L} &= \log c_{it} + \beta \log\left(1+r_{t+1}\right) s_{it} + \gamma \log\left(1-n_{it}\right) + \eta \log \theta_{it} e_{it}^{\varphi_1} g_{rt}^{\varphi_2} h_{it}^{\varphi_3} H_{rt}^{1-\varphi_1-\varphi_2-\varphi_3} \\
&\quad + \lambda_t \left[\left(1-\tau_t\right) \tilde{w}_{ut} n_{it} h_{it} - b \tilde{w}_{ut} h_{it}^{-1} - c_{it} - s_{it} - e_{it}\right] \qquad (5.C13)
\end{aligned}
$$

The First Order Conditions (FOCs) are:

$$
\begin{aligned}
c_{it}: \quad \frac{1}{c_{it}} &= \lambda_t && (5.C14)\\
s_{it}: \quad \beta \frac{1}{s_{it}} &= \lambda_t && (5.C15)\\
e_{it}: \quad \eta \varphi_1 \frac{1}{e_{it}} &= \lambda_t && (5.C16)\\
n_{it}: \quad \gamma \frac{1}{1-n_{it}} &= \lambda_t \left(1-\tau_t\right) \tilde{w}_{ut} h_{it} && (5.C17)\\
\lambda_t: \quad c_{it} + s_{it} + e_{it} &= \left(1-\tau_t\right) \tilde{w}_{ut} n_{it} h_{it} - b \tilde{w}_{ut} h_{it}^{-1} && (5.C18)
\end{aligned}
$$

Solving equations (5.C14), (5.C15), (5.C16), (5.C17), and (5.C18) simultaneously delivers the results documented in Lemma 5.

Chapter 6

Conclusion

In this chapter, we first gather the main findings from Chapter 3, Chapter 4, and Chapter 5. After that, we discuss the policy implications from a more broader perspective. Finally, we briefly talk about the directions for further studies.

6.1 Conclusion

In any economy, government intervention is nearly indispensable due to market failures and market imperfections. It is important to understand the characters of government intervention in contemporary economy. A better understanding about the impacts of different categories of government interventions on the aggregate economy, specifically, output and unemployment, requires a complete assessment about the impacts of both the supply side policies and demand side policies, through which government intervenes in the economy, on the aggregate output and the labor market.

This dissertation concentrates on evaluating the impacts of fiscal policies from the demand side of government intervention and the labor market regulations from the supply side of government intervention on output and unemployment. In particular, we investigate three important questions associated with evaluating the impacts of different categories of government interventions on aggregate output and the labor market. First, which category of the different government spending expenditures is more effective in stimulating the economy, and why is it more effective? Second, how do changes in different government spending components and distinctive categories of taxes influence the labor market variables during recessions? Third, what are the effects of changing fiscal policies and labor market regulations simultaneously on the aggregate economy?

To appropriately address these three questions concerning the dynamic effects of different categories of government interventions on the aggregate economy, different theoretical frameworks and distinctive economies, which are suitable to investigate each of these three questions under considerations, are employed in Chapter 3, Chapter 4, and Chapter 5, respectively.

The first important question, i.e., which component of government wage expenditure, government investment, and government consumption expenditure is more effective in boosting output and reducing unemployment, and why it is more effective, is examined in Chapter 3. Our empirical studies employing the U.S. data show that government wage component is the more effective component in stimulating the economy, according to the estimated cumulative output and unemployment multipliers.

Our theoretical analysis reveals that the mechanisms though which distinctive government spending affects the aggregate output and the labor market are different. Moreover, government wage component is more effective than the other components because it affects the labor market both directly via influencing the government employment, as well as indirectly through the traditional induced demand for labor.

In addition, our quantitative analysis demonstrates that raising government wage component financed by lowering government consumption component generates the largest cumulative output multipliers and cumulative unemployment rate multipliers: 20 percent increase of government wage expenditure raises the cumulative output multiplier by 5.25 percent and reduces the cumulative unemployment rate multiplier by 8.22 percent, respectively.

The second important question, i.e., how changes in different government spending components and distinctive categories of taxes affect the labor market variables during recessions, is examined in Chapter 4. This question is studied through employing the episode of the 1990s in Japan, when the unemployment rate surged from 2.08% in 1990 to 5.40% in 2002. Meanwhile, the fiscal policies were changed by the Japanese government to cushion the labor market. From the spending perspective, the share of government wage expenditure, government investment, and government consumption expenditure in GNP changed differently from 1990 to 2002. From the tax aspect, the consumption tax was raised from 0.03 to 0.05 in 1997, while the labor tax and capital tax were fairly stable according to Mendoza et al. (1994) and Esteban-Pretel et al. (2010).

To evaluate the impacts of these changes in different fiscal policy instruments on the unemployment rate in Japan during the 1990s, we build, calibrate, and simulate a dynamic general equilibrium model with search and matching frictions in the labor market, and a productive government sector. The model is calibrated to match the Japanese economy in 1990, and is solved employing the two-boundary problem solution method.

Our simulation results demonstrate that if government investment and wage didn't change, the unemployment rate in 2002 would be 7.56% and 0.36% lower, respectively, while it would be 5.90% higher if government consumption did not change. The reason is that the wealth effect increases the value of employment and decreases the value of unemployment, leading to rising matching surplus, which encourages hiring and hence reduces unemployment. Meanwhile, 10% tax reductions in labor, capital, and consumption after 1990 reduces the unemployment rate in 2002 by 15.87%, 9.59%, and 13.83%, respectively. The effects of different tax reductions are not the same because distinctive categories of taxes affect the economy heterogeneously: labor tax directly influences the value of employment, capital tax affects the capital accumulation and hence the value of posting a vacancy, while consumption tax affects the household wealth.

The third important question, i.e., how changes in the fiscal policy and labor market regulations affect the aggregate economy, is examined in Chapter 5. This question is motivated by the experience of the Chinese economy since the late 1970s, a period of rapid economic growth accompanied by enlarging interregional income inequality. Meanwhile, there exist labor mobility barriers across regions, and the urban-biased allocation of government education expenditures. The labor mobility barriers and urban-biased government education expenditures have been considered as two of the main determinants of this enlarging interregional income inequality.

To investigate how these two elements affect the urban-rural income inequality, we develop a growth model with two regions, where labor mobility barriers affect the cost of migration across regions, while government education expenditures influence the accumulation of regional human capital. With several tractability assumptions, we characterize the equilibrium paths of regional mean incomes, with which we could evaluate the potential impacts of reducing labor mobility barriers and reallocating government education spending on interregional income inequality through employing comparative dynamics analysis.

Our theoretical analysis demonstrates that equally reallocating government education spending across regions mitigates the interregional income inequality, because this reallocation reduces the urban mean income while it raises the rural mean income. However, only reducing the labor mobility barriers does not necessarily decrease the urban-rural income inequality since it generates counteracting effects on the mean income of the rural stayers and that of the rural migrants, the total effect on rural mean income could be either positive or negative. Moreover, the combination of these two policies tends to shrink the interregional income inequalities if the effect from reallocating government resources dominates.

Our studies in each of these three chapters of this dissertation have their policy implications, respectively, now we outline and discuss their policy implications in the next section.

6.2 Policy Implication

Through examining three concrete questions concerning the fiscal policy from the demand side and labor market regulation from the supply side, this dissertation evaluates the impacts of different categories of government interventions on aggregate output and the labor market in Chapter 3, Chapter 4, and Chapter 5, respectively. Their policy implications are outlined and discussed in this section.

Chapter 3 investigates the dynamic effects of different government spending components on output and unemployment both empirically and theoretically, our empirical studies and theoretical investigations provide several policy implications. First, consistent with the statement of Poterba (2011) and Rogoff (2011), we demonstrate that distinctive categories of government spending generate heterogenous effects on output and unemployment, which implies that government could achieve specific economic target by employing government spending in certain utilization purpose. For example, if government wants to more effectively reduce unemployment, increasing government wage expenditure and hiring more government employees could be a candidate instrument. Alternatively, if government intends to strengthen the social infrastructure, a larger fraction of the government resources should be devoted to government investment.

Furthermore, according to the estimated and simulated cumulative output and unemployment multipliers, government wage expenditure is more effective in stimulating the economy than the other components. Which implies that theoretically it is possible to increase the total effectiveness of aggregate government spending in terms of boosting output and reducing unemployment, through reallocating the government resources from the less effective investment component or consumption component to the more effective wage component, moreover, our counterfactual experiments confirms this theoretical proposition. Meanwhile, we also realize that in reality, government investment is devoted to social infrastructure, while government consumption is spent on national defense and public education, politically it may be difficult to reduce these two components since both of which are indispensable in real economy activities. However, the more realistic and implementable implication is that during recessions, if government want to spend extra amount of resources to stimulate the economy, like in the American Recovery and Reinvestment Act in 2009 (ARRA), our analysis suggests that a large proportion of these extra amount of resources ought to be devoted to government wage expenditure, if the fundamental policy target of the government is to more effectively boost output and to reduce the unemployment rate.

In addition, with the directed search and matching framework, we are able to observe the fluctuations of both the aggregate unemployment and the sectoral unemployment, an interesting finding is that after government spending increases, the share of unemployed people searching in the private sector increases, which implies that providing hiring subsidies to the private sector firms would also help to reduce unemployment, because this policy encourages hiring by the private sector firms, and hence reduces unemployment.

Chapter 4 quantitatively evaluates the impacts of fiscal policy changes on unemployment during the Lost Decade in Japan, our quantitative analysis and findings from counterfactual experiments deliver some policy implications. First of all, consistent with what we find in Chapter 3, different categories of government spending components affect the unemployment rate heterogeneously, thus government could attain different policy goals through employing one specific category of spending component. For instance, if the fundamental policy goal of government is to raise the quality of public education, a larger fraction of the aggregate government spending could be devoted to government consumption component.

Furthermore, our simulation results imply that both tax reduction policies and spending expansion policies could achieve the goal of cushioning the labor market, i.e., reducing the unemployment rate, during the 1990s. However, during the Lost Decade, the Japanese government did not adopt the contractionary tax policy, as according to Mendoza et al. (1994) and Esteban-Pretel et al. (2010), the capital tax and labor tax were relatively stable, moreover, the consumption tax was raised from 0.03 to 0.05 in 1997. The divergence between our analysis and what the government did implies that, actually, the Japanese government could reduce the unemployment rate in the 1990s more than what they achieved, if they adopted the tax reduction policies. More generally, countercyclical fiscal polices indeed contribute to stimulate the economy, i.e., reduce unemployment and boost the output, during recessions.

In addition, during the 1990s, although the share of aggregate government spending in GNP increases, its three distinctive elements are moving in different directions, for instance, the share of government investment in GNP actually decreases while the share of government consumption in GNP increases, as demonstrated by our simulation results, these opposite changes generate counteracting effects on the unemployment rate, i.e., the decrease in government investment increased the unemployment rate while the increase in government consumption reduced unemployment. Therefore, the policy implication is that policy makers and government should consider the interaction among different policy tools when more than one fiscal policy instruments are employed to stimulate the economy during recessions.

Chapter 5 examines the potential impacts of removing labor mobility barriers and reallocating government education expenditures on the urban-rural income inequality in China since the late 1970s from a theoretical perspective, our qualitative investigations suggest several policy implications. First, theoretically speaking, since government education spending affects the regional human capital and hence mean income within each region, a more equal reallocation of public education resources across regions would reduce the interregional income inequality, which is defined as the ratio of urban to rural mean incomes, because this equal reallocation tends to reduce the mean income of urban residents while increase the mean income of rural residents. Meanwhile, we also realize that in reality, it might be not easy to implement this reallocation, due to the long tradition of urban-biased government policies. However, under the current scenario of enlarging interregional income inequality in China, if government could reallocate the education resources more equally across regions, we expect that the urban-rural income inequality would be significantly reduced to some extent.

Furthermore, reducing the labor mobility barriers makes migration across regions much easier, which increases the supply of total urban effective labor and reduces the aggregate supply of total rural effective labor, as the labor market within each region is perfectly competitive, the urban wage rate would decrease while the rural wage rate would increase after further removing the labor mobility barriers. Thus, this policy generates two counteracting effects on the aggregate rural mean income, it raises the mean income of rural stayers but reduces the mean income if rural migrants, hence, simply removing labor mobility restriction does not necessarily reduce the interregional income inequality.

In addition, how about the policy combination of reducing labor mobility barriers and reallocating government education resources simultaneously? Theoretically speaking, the aggregate effects could be either positive or negative, however, this policy mix tends to shrink the urban-rural income inequality if the mitigating effects from reallocating education resources dominates. Therefore, what the Chinese government is doing now, i.e., they gradually erases the difference between urban *hukou* and rural *hukou*, as a single policy instrument which is not enough to mitigate the rising interregional income inequality, therefore, the reallocation of government education resources should also be considered.

Broadly speaking, concerning the impacts of government interventions on aggregate economy, in terms of fiscal policies and labor market regulations, our analysis in this dissertation implies that different policy instruments generate heterogenous impacts on the aggregate economy. In addition, different changes of certain policy instruments would even exert counteracting effects on aggregate economic activities. Therefore, elaborate considerations about the potential impacts of different policy instruments and how their interactions affect the aggregate economy are indispensable in the process of policy designing and implementing.

6.3 Further Research

Government intervention is a much more broader concept than what we discussed here, our studies in this dissertation suggest several research directions that deserve further exploration in the near future.

Concerning the characters of different government spending components, we still have lots of interesting aspects to investigate. First, the magnitudes of the responses of labor market variables would be slightly different if job destructions are endogenous (Kuo and Miyamoto, 2014), a potential research direction is to explore how the destruction mechanism affects the labor market dynamics, through comparing the responses of aggregate macroeconomic variables in models with endogenous destruction and in models with exogenous destruction. Second, distortionary taxes are abstracted from our theoretical framework, it is interesting to explore what would be the impacts of different fiscal instruments on output and unemployment if distortionary taxes are introduced. Third, most of the existing models employ homogenous agent assumption, however, as noted by Mayer et al. (2010), heterogeneous agents really matter for the responses of some macroeconomic variables, which is also a direction to pursue. In addition, modeling the labor force participation decisions as in Bruckner and Pappa (2012) and Bermperoglou et al. (2012) could also be a direction to further investigate in terms of model building.

There are several interesting directions to pursue, concerning the changes of fiscal polices in Japan's Lost Decade. First, in our framework, hours worked in the private sector is exogenously set following Esteban-Pretel et al. (2010), it deserves further investigation if hours are endogenously determined. Second, we employ a random search model, what would be the effects if we employ the directed search framework? Does the assumption about the search behavior matter for the effects of fiscal policies? These questions could be further investigated in our further study. In addition, monetary policy is abstracted from our study, how does the interaction between fiscal policy and monetary policy influence our results, which also deserves further investigations in our future studies.

Coming to the impacts of labor market policies and fiscal policies in China, there are also several things that deserve further exploration. First and foremost, the quantitative studies, we didn't conduct quantitative simulations for the last chapter due to the availability and reliability of the data at our hand. However, the quantitative exercise should be further conducted in our future research work with revised models and reliable data. Second, how to model or to introduce labor mobility restrictions? Because in the literature, there are not many studies concerning this concrete issue, our specification is an endeavor through modifying the specification of Fu (2013), which should be further improved and investigated in our future study. Moreover, the interaction of supply side policy with other demand side policy, such as monetary policy, could also be explored in our further studies.

Generally speaking, we could further explore the characters of demand side policies, in particular, the interactions between demand side policies and supply side policies on aggregate output and the labor market in our further academic endeavors. We do hope that our further endeavors would make more contributions to the understandings about the impacts of government interventions on the aggregate economy.

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