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Abstract

Rich volume of literature points out that many developing countries have experienced procyclical macroeconomic policies in recent period. In this paper, I theoretically investigate an optimal monetary policy in an economy where an imperfect infrastructural development influences on economic dynamics and the cyclicality of fiscal and monetary policies. In a simple new Keynesian Dynamic Stochastic General Equilibrium (DSGE) model with nominal price rigidity and monopolistic competition, I add a real adjustment cost that is created by a government spending spread between current and natural levels of the public expenditures. This cost captures a negative effect of underdeveloped public infrastructure on key macroeconomic policy variables in the developing economies. In the model, this real adjustment cost worsens the trade-off of New Keynesian Phillipas Curve and IS relation. As a result, solving optimal policy problem with linear-quadratic welfare loss measurement and analyzing it numerically, I find that the optimal fiscal and monetary policy tend to be more procyclical and the economy experiences high level of volatility when the degree of severity of the imperfect infrastructural development is relatively high. Comparing alternative monetary policy regimes under Taylor rule, I find that the benchmark Taylor rule with moderate inflation stabilization targeting and aggressive output stabilization targeting is optimal.

Keywords: Developing Countries; Monetary Policy; Procyclical Fiscal Policy; Infrastructure; Stabilization.

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1 Introduction

Recent report by Frankel et al. (2011) demonstrates a sharp contrast between industrialized and developing countries in terms of cyclicality of macroeconomic policies. Many of developing countries have experienced a significant level of procyclical fiscal and monetary policy while most developed countries have had acyclical or countercyclical policy regimes in recent years. Why do those developing countries have the puzzling policy issue? Is the procyclical policy optimal for them? If so, what is the best combination of fiscal and monetary policy to stabilize their business cycle fluctuations? To answer these questions, I build a simple new Keynesian Dynamic Stochastic General Equilibrium (DSGE) model with an assumption of a real friction, which is created by a spread between current and natural levels of government spending. I then evaluate alternative monetary policy regimes to find the optimal package of fiscal and monetary policies under those economic circumstances.

In the model, in addition to the widely used nominal frictions in new Keynesian model, nominal price rigidity and monopolistic competition in a production sector, I introduce a real friction of the government spending spread which is captured from the fact that many emerging market or developing economies still have a certain level of the imperfect infrastructural development that possibly hampers further economic growth and sustainable stabilization of business cycles.[1] This main assumption is represented in the model as a type of an adjustment cost which is generated when current level of public expenditure is different from the efficient level of it. This cost can be interpreted as an example of the imperfect infrastructural development. The government spending is considered as a physical public expenditures which is consumed in the form of utility function of representative households. A degree of the effect of the government spending spread is scaled by a specific parameter ξ in the model, which is a key to explain the main findings of this paper.

In this closed economy model, the main findings are threefold. First, I find that the degree of the government spending spread affects on the severity of procyclity of fiscal and monetary policy. As the negative effect of the imperfect infrastructural development on the economy increases, fiscal and monetary policies tend to be more procyclical. Second, with higher degree of the negative effect, the

[1] Straub (2008) empirically points out that there is a significant level of deficiencies of infrastructure in many developing countries and the lack of public service is strongly linked to the discouragement of macroeconomic development.

economy experiences higher level of volatility, and the trade-off between inflation and output gap stabilization is worsened by the effect. Third, by comparing alternative policy parameters in Taylor rule, I find that the standard weight on the inflation stabilization targeting with stronger motive in output gap stabilization than the original Taylor rule suggested by Taylor (1993) can achieve better economic consequences. Changes in the effect of imperfect infrastructural development, captured by the parameter value of the government spending spread, have an effect on the trade-off between inflation and output gap stabilization policy problem through direct and indirect channels. In the direct channel, the higher value of the effect steepens the slope of New Keynesian Phillips Curve (NKPC) and IS relation, and amplifies the effect of exogenous shock in the relations. This results in worsened trade-off in the relations that policy makers face in decision making process. The exacerbated trade-off forces policy makers to bear higher level of volatility in policy instruments to create an effective level of inflation in order to stabilize an output changed due to the exogenous shock. The policy makers also should conduct higher level of changes in the instruments to fully stabilize the economic fluctuations. This mechanism mainly induces the first two findings of the paper. In indirect channel, the real friction changes the weight on each variable in the welfare-based objective function of policy makers. In the linear-quadratic form of the welfare loss function, changes in degree of the imperfect infrastructure effect can amplify or worsen a relative weight on policy variables. With this change in relative importance of each variable in the objective function, policy makers perceive different level of effectiveness of fiscal or monetary policy. This structural change also contributes to the main findings.

The economic logic behind the main result of the paper is simple. The real friction is created from the difference between current and natural levels of government spendings. It represents a part of fiscal inability to operate the economy in most efficient way. It means that, the fiscal authority cannot fully stabilize the output volatility any more without sacrificing higher volatility in inflation. This worsened trade-off between policy objectives gives policy makers a motivation to use stronger policy instruments to fully stabilize the economy. This is the main reason why the procyclical policy trend is deepened with higher level of the real friction. Furthermore, since the nature of the real friction is a type of adjustment cost in fiscal operation and it is increasing with higher level of differences between current and efficient level of the public spending, the higher level of the cost creates higher level of volatility in fiscal spending when procyclical policy trend is deepened and the fiscal policy maker uses stronger policy tools that widens the gaps. This is the reason why fiscal part responses to the change of infrastructural development more sensitively than monetary policy part. In this environment, monetary policy should be more aggressive on output stabilization to compensate the lack of fiscal policy due to the worsened trade-off. But the monetary policy should not be too dedicated to stabilizing inflation because in this economic condition the monetary authority must give up too high level of volatility in its policy instrument when it tries to accomplish the desired level of inflation or deflation to stabilize the changed output.

The main contribution of this paper is that, it gives another way to think about the causality of procyclical fiscal and monetary policy and thus it seeks to find an optimal stabilization macroeconomic policy under that circumstances. There has been a rich volume of literature on the possible reasons for procyclity in developing economies, but unfortunately rare chance of global consensus has been driven. This paper suggests that, without considering political economy dimensions such as Talvi & Végh (2005) or Alesina & Tabellini (2005), the lack of infrastructure, a common feature across the most of developing countries, can reasonably generate the puzzling tendency of policy regimes. Furthermore, the paper argues that under that kind of economic environment, a procyclical macroeconomic policy is logically optimal, as a possible solution for the puzzling economic phenomena. Another potential contribution of this paper to the related literature is that, the paper opens a new room for a discussion on policy implications of business cycles with infrastructural development. Infrastructure or public investment has been widely studied in development or growth literature as a main factor of economic stimulation, but rarely discussed in business cycle literature. Furthermore, a research on real frictions caused by the imperfect development of public infrastructure combined with a nominal rigidity of prices has been little ignored in the field, although the importance of the effect of the friction on the economic volatility in many developing countries has been increased. Even though the paper has a limitation of closed economy model that ignores the effect of international dimension such as an effect of exchange rate pass-through or foreign capital flows on the interest rate determination, this paper still has an edge by providing an insight on the policy implications under circumstances of imperfectly supplied infrastructure that the monetary authority should consider the public spending spread in order to achieve optimally stabilized macroeconomic variables.

2 Literature Review

In this section, I discuss related literature to the key features of the model in this paper. The model mainly focuses on the effect of imperfectly developed public expenditure on economic dynamics. This real adjustment cost illustrates the gap between the current and the natural levels of government spendings, which exemplifies the lack of infrastructural development affecting business cycle of the economy. Baier & Glomm (2001), Rioja (1999) and Rioja (2003) examine the effect of development in infrastructure on economic development in neoclassical fashion. Especially Baier & Glomm (2001), putting distortionary taxes in the model, find that the infrastructural development can effectively stimulate the economic growth with appropriate level of elasticity of substitutions between inputs. Azzimonti et al. (2009) build a Ramsey policy problem with alternative technical approaches, to compare welfare losses between commitment and discretion cases when productive public capital is introduced in the model. It shows that welfare loss under discretion relative to the commitment case is minimal. Leeper et al. (2010) build a neoclassical model to find the delayed implementation effect of government investment on the economics growth. The paper reveals that an unanticipated delay of public investment can possibly discourage labour and output growth in short run.

This paper is also interested in a procyclity of macroeconomic policies. Validity of procyclical fiscal policy has long been an important issue of debate in related literature, while many researchers have tried to find the main determinant of the procycality on the other hand. Papers such as Kaminsky et al. (2004) and Alberola & Montero (2006) empirically demonstrate the recent trend of developing economies that have exhibited procyclity of important macroeconomic indicators including fiscal and monetary policies. Many papers in the literature have made an effort to validate that kinds of procyclical economic policies with variety of theoretical approaches. Talvi & Végh (2005) insist that even in an economic boom sustaining budget surplus is costly for some developing countries because there is an ongoing political pressure to spend more tax revenue. While Ilzetzki (2011) and Alesina & Tabellini (2005) also focus on the political economy side factors on the procyclicality, Tornell & Lane (1999) endogenously solve the unexpectedly increased fiscal redistributions by using the term ”voracity effect.” Inspired by recent data set, Mendoza & Oviedo (2006) point out that governments in emerging market economies behave like a ”tormented insurer,” which means that the fiscal authority spends more money on private sector to defend the reduction of variability of revenue as economy enjoys boom, and thus it creates the procyclical fiscal policy regimes in those regions. Upon these findings, Demirel (2010) argues that in a small open economy model with the existence of country spread, optimal stabilization polity is procyclical.

Methodologically this paper aims at finding a mix of optimal fiscal and monetary stabilization policy by using Ramsey problem with linear-quadratic welfare loss function. The paper follows pioneering works of papers such as Benigno & Woodford (2012), Schmitt-Grohé & Uribe (2003), and Schmitt-Grohé & Uribe (2004). The papers enlighten the way of finding both optimal fiscal and monetary policies simultaneously by implementing well-defined Ramsey problems. Especially Benigno & Woodford (2012) provide an ample theoretical background for the benefit of linear-quadratic welfare measure. According to the paper, the functional form gives the enough possibility of unique solution as well as easiness of comparing alternative policy regimes.

3 Model

The welfare analysis of alternative monetary policy regimes starts with a dynamic stochastic general equilibrium model of an economy. Based on the benchmark features of a closed economy new Keynesian model such as staggered final goods price setting following Calvo (1983) and monopolistic competition in production sectors, I add a real adjustment cost in the economy as a main distortion, which is a negative effect of a government expenditure spread between current and permanent levels of it.

3.1 Households

Identically populated households live infinitely and maximize the discounted expectation of a lifetime utility function. Preferences of a representative household is defined by

$$U_0 = E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma}}{1-\sigma} + \chi_G \frac{G_t^{1-\phi}}{1-\phi} - \chi_L \frac{L_t(i)^{1+\varphi}}{1+\varphi} \right] \tag{1}$$

where C_t, G_t, and L_t denote the level of composite private and government consumption and labor supplied, respectively. E_t is defined by an expectation conditional on all information given at time t. For parameters, $0 < \beta < 1$ is time discounting factor, $\sigma > 0$ and $\phi > 0$ stand for inter-temporal elasticity of substitution of private and public consumption, and $\varphi > 0$ is a reverse of an elasticity of labor supply. χ_G and χ_L are relative weights on public consumption and disutility of labor supply but I assume that they are normalized by one hereafter for convenience of calculation. The composite private or public consumption is assumed to be a continuum of differentiated goods produced by numerous final goods producers indexed by $i \in [0, 1]$ and defined by

$$C_t = \left(\int_0^1 C_t(i)^{\frac{\delta-1}{\delta}} di \right)^{\frac{\delta}{\delta-1}} \tag{2}$$

$$G_t = \left(\int_0^1 G_t(i)^{\frac{\delta-1}{\delta}} di \right)^{\frac{\delta}{\delta-1}} \tag{3}$$

where $\delta > 1$ is an intratemporal elasticity of substitution between differentiated goods. The labor supply is aggregated by individual labours dedicated to each differentiated production sector:

$$L_t = \int_0^1 L_t(i) di \tag{4}$$

Consumption price index (CPI) is calculated by

$$P_t = \left(\int_0^1 P_t(i)^{1-\delta} di \right)^{\frac{1}{1-\delta}} \tag{5}$$

Furthermore, a representative household's demand function for each differentiated private good is calculated by

$$C_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\delta} C_t \tag{6}$$

The budget constraint for the representative household at period t is determined by

$$P_t C_t + B_t \leq W_t L_t + R_{t-1} B_{t-1} + T_t + \Gamma_t \tag{7}$$

where B_t is nominal bond holdings printed by government, R_t is the gross interest rate set by policy authority, W_t denotes the nominal wage for unit amount of labour, T_t stands for a lump-sum type tax or transfer from government, and γ_t is the the profit of firms since the firms are assumed to be held my households. To prevent the possibility of Ponzi scheme, the following additional condition is needed:

$$\lim_{k \to \infty} E_t \left(\prod_{j=0}^{k} \frac{B_{t+k+1}}{R_{t+j}} \right) \geq 0 \tag{8}$$

The household's problem is defined by the maximization of (1) with respect to C_t, L_t, and B_t, subject to (7) and (8). The first order necessary conditions are calculated by

$$\frac{W_t}{P_t} = L_t^{\varphi} C_t^{\sigma} \tag{9}$$

$$1 = \beta E_t R_t \left(\frac{P_t}{P_{t+1}} \right) \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \tag{10}$$

Equation (9) indicates the mechanism of labour supply or real wage determination. The real wage is determined by weighted combination of labour supply and private consumption. Equation (10) is a simple Euler equation that relates intertemporal consumption streams to future inflation rate, $\frac{P_{t+1}}{P_t}$ and nominal interest rate, R_t, which are weighted by time discounting factor, β. This also represents that the marginal utility for the private consumption at the current period should be equal to the discounted marginal utility of future consumption.

3.2 Firms

Production sector is assumed to have infinitely many firms indexed by i on the unit interval $[0, 1]$, and each firm produces a differentiated good in a monopolistically competitive environment. The each firm has a constant return to scale technology,

$$Y_t(i) = A_t N_t(i) \tag{11}$$

where $Y_t(i)$ is an amount of output for good i, A_t is a economy-wide common productivity shock that follows a stochastic process which will be defined later, and $N_t(i)$ is an amount of labor demanded for sector i. Cost minimization problem for each firm solves for a nominal marginal cost which is denoted by $MC_t(i)$, to be a function of nominal wage and productivity shock:

$$MC_t(i) = \frac{W_t}{A_t} \tag{12}$$

Furthermore, the aggregate level of labor demanded is a simple sum of each sector's amount of labor demanded:

$$N_t = \int_0^1 N_t(i)di \tag{13}$$

Following Calvo (1983) and Yun (1996), the model introduces another imperfection of the economy, a staggered price setting. Each firm has a probability of $0 < \theta < 1$ to hold its price at any date. In other words, with the probability $1 - \theta$, a typical firm newly updates its price at each period. θ is understood as a degree of price stickiness. Therefore, a single firm's price $P_t(i)$ is a weighted sum of $P_t^*(i)$, the price set by the firm at every period, and the price of the previous period, $P_{t-1}(i)$. A price level of each firm set at time t is then given by

$$P_t(i) = (1-\theta)P_t^*(i) + \theta P_{t-1}(i) \tag{14}$$

At each period, a single firm i encounters a profit maximization problem with respect to $P_t^*(i)$,

$$max_{P_t^*(i)} \sum_{s=0}^{\infty} E_t \Lambda_{t,t+s} \theta^s Y_{t+s}(i) \left(P_t^*(i) - MC_{t+s}(i)\right) \tag{15}$$

such that

$$Y_{t+s}(i) \geq \left(\frac{P_t^*(i)}{P_{t+s}}\right)^{-\delta} Y_{t+s} \tag{16}$$

$$MC_{t+s}(i) = \frac{W_{t+s}}{A_{t+s}} \tag{17}$$

$$Y_t(i) = C_t(i) + G_t(i) \tag{18}$$

and (2) and (3), where $\Lambda_{t,t+s}$ is a stochastic discount factor defined by

$$\Lambda_{t,t+s} = \beta^s \left(\frac{P_t}{P_{t+s}}\right) \left(\frac{C_t}{C_{t+s}}\right)^{\sigma} \tag{19}$$

The first order condition of the maximization problem is reduced to

$$P_t^*(i) = \frac{\delta}{\delta - 1} \frac{E_t \sum_{s=0}^{\infty} \theta^s \Lambda_{t,t+s} \left(\widehat{MC_{t+s}}(i) P_{t+s}^{\delta-1} Y_{t+s} \right)}{E_t \sum_{s=0}^{\infty} \theta^s \Lambda_{t,t+s} \left(P_{t+s}^{\delta-1} Y_{t+s} \right)} \tag{20}$$

where $\widehat{MC_{t+s}}(i)$ denotes a real marginal cost, $\dfrac{MC_{t+s}(i)}{P_{t+s}}$. Note that as θ converges to zero, i.e., the price goes to the fully flexible state, the equilibrium price level also settles to the benchmark level, $P_t(i) = \mu \widehat{MC_{t+s}}(i)$, where $\mu = \frac{\delta}{\delta-1}$, the markup revenue. Since the symmetric equilibrium is assumed, all firms solve identical problems at each period, and thus one can remove i notation hereafter. $P_t^*(i) = P_t^*$ and $MC_{t+s}(i) = MC_{t+s}$. Combining CPI definition (5) and (14) gives the clearer version of the inflation rate:

$$\Pi_t \equiv \frac{P_t}{P_{t-1}} = \left((1-\theta) \left(\frac{P_t^*}{P_{t-1}} \right)^{1-\delta} + \theta \right)^{\frac{1}{1-\delta}} = \left((1-\theta) {\Pi_t^*}^{1-\delta} + \theta \right)^{\frac{1}{1-\delta}} \tag{21}$$

where Π_t^* is defined by $\frac{P_t^*}{P_{t-1}}$.

3.3 Government

There are two policy tools and they are separated by two independent authorities, fiscal and monetary policy authorities. A benevolent fiscal authority provides a public expenditure, G_t, to the private sector and collects tax by lump sum fashion along with printing one-period risk free nominal bond, B_t, with price R_t to finance it. G_t is an aggregation of $G_t(i)$ following (3), and thus the public demand function for any variety i is calculated by

$$G_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\delta} G_t \tag{22}$$

There exists an adjustment cost if current level of the fiscal spending is different from the natural level of it. Let X_t^n be the natural rate of an arbitrary variable X_t at time t and it is said to be the state where all prices are fully flexible without any market distortions. This difference, defined by $(G_t - G_t^n)$, is not fully cleared even when the economy reaches at the steady state level. A steady state means all endogenous variables are stable enough so that there is almost no changes on them, still containing one or more market imperfections if it is assumed to be at the beginning of the economy and continue to have the frictions permanently. Therefore, there is no sound guarantee that the difference, in short term, $\widehat{G_t}$, will be cleared at steady state level. Furthermore, $\widehat{G_t}$ is a real adjustment cost departing from the traditional nominal rigidity assumptions such as staggered price or wage, and the real adjustment cost can be interpreted as the difference between the level of government service provided at the current stage and the "desired" level of the spending, i.e., the efficient level. For instance, assuming that an economic growth or stabilization of business cycle is positively related to the level of infrastructural development and a function of the growth is convex, the effect of the public spending on those macroeconomic performances should be relatively significant at a very begging stage where infrastructures are in immature level, but the effect will be minimal when it is perfectly serviced at a very satisfactory level. The real friction occurs when current level of expenditure is not met with the desired level, even including a surplus situation. A budget constraint of the fiscal policy maker is then assumed to be balanced at every period,

$$P_t G_t + R_{t-1} B_{t-1} = -T_t + B_t - P_t \frac{\xi}{2}(G_t - G_t^n)^2 \tag{23}$$

where $\xi > 0$ captures the degree of the adjustment cost. As ξ converges to zero, the effect of the government spending gap on the economy becomes smaller. This means that the economy is more independent of the real friction. This does not mean that the economy has the higher level of infrastructural development, but it means that the effect of the imperfect infrastructure is relatively modicum. Potential factors affecting the degree of ξ is not explicitly demonstrated in this model, but some evidences of the higher level of xi in developing countries are discussed in several papers such as Talvi & Végh (2005). In developing countries, because of tax evasion or political corruption, it is hard for a central government to have a fully flexible targeting mechanism to minimize the effect of the gap between current level and natural level of fiscal spending. For instance, in recession, since developing countries may meet worse situation of tax evasion, they are not able to aggressively cancel the gap immediately. Therefore, the higher level of ξ captures higher level of exogenous factors that amplify the effect of the government spending spread. It is important to note that, the zero value of ξ does not replicate developed countries situation. There should be further consideration and modification of the model to correctly express the developed countries version of the economy, and regardless of the value of xi, this model represents the case of developing economies.

On the other side, a monetary authority sets the nominal interest rate, R_t, at every period. A simple Taylor rule is implemented as a benchmark one.

$$R_t = R\left(\Pi_t\right)^{\gamma_\pi}\left(\frac{Y_t}{Y_t^n}\right)^{\gamma_y} \tag{24}$$

where γ_π and γ_y are policy parameters. Therefore, the two idiosyncratic policy authorities choose $\{R_t, G_t, T_t\}_{t\geq 0}$ with uniquely determined $\{B_t\}_{t\geq 0}$.

3.4 Competitive Equilibrium

A competitive equilibrium is a set of endogenous variables $\{C_t, G_t, L_t, N_t, Y_t, B_t, MC_t\}_{t\geq 0}$ with prices $\{P_t, P_t^*, R_t, W_t\}_{t\geq 0}$ and an exogenous stochastic process $\{A_t\}$ satisfying (9), (10), (12), (20), (21), (23), (24), goods market clearing condition,

$$Y_t = C_t + G_t + \frac{\xi}{2}(\widehat{G_t})^2 \tag{25}$$

bond market clearing condition,

$$B_t = 0 \tag{26}$$

labour market clearing condition,

$$L_t = N_t \tag{27}$$

the aggregate production,

$$Y_t = A_t N_t \tag{28}$$

and the specification of the common technology shock A_t which follows AR(1) process

$$\log A_t = \rho \log A_{t-1} + \varepsilon_t^a \tag{29}$$

4 Qualitative Analysis

In this section, I discuss about economic implications of the main assumption of the model described in the above section in detail. From the planner's problem, I obtain an important log-linearized version of equations that reflect the distorted effect of imperfectly serviced public expenditures. And I also define natural rates of endogenous variables expressed in terms of the exogenous shock and parameter values. After then, I characterize a Ramsey policy problem to obtain an insight on the policy implications. To do so, I construct a linear-quadratic welfare loss function following Woodford (2003) and Benigno & Woodford (2012), that has a benefit of capability of comparing alternative policy regimes.

4.1 Procyclical Economic Policy

Price determination (20) can be solved forward and log-linearized that provides a so-called new Keynesian Phillips equation:

$$\pi_t = \kappa \widehat{mc_t} + \beta E_t \pi_{t+1} \tag{30}$$

where $\kappa = \frac{(1-\theta)(1-\theta\beta)}{\theta}$, and now $\widehat{mc_t}$ is redefined by the difference between log deviation of real marginal cost at time t from its steady state and the log of its natural level value, $\log \frac{1}{\mu}$. (30) states that the current level of inflation is affected by the real marginal cost, including the effect of monopolistic competition by a reverse of markup revenue and expectation of future inflation. To replace $\widehat{mc_t}$ with expressions of familiar endogenous variables, I use labor supply equation (9), labor market clearing condition (27), and (28) combined with the specification of the marginal cost (12). After some straightforward calculations I express the real marginal cost in terms of Y_t and C_t:

$$\begin{aligned} \widehat{MC_t} &= (Y_t)^{\varphi} (C_t)^{\sigma} (A_t)^{-(\varphi+1)} \\ &= Y_t^{\varphi} A_t^{-(\varphi+1)} (Y_t - G_t - \frac{\xi}{2}(\widehat{G_t})^2) \end{aligned} \tag{31}$$

By log-linearizing (31), one can obtain expression of the log deviation of the real marginal cost in terms of log deviations of output, y_t, government spending, g_t, and the stochastic process, a_t:

$$\widehat{mc_t} = (\varphi + \sigma\frac{Y}{C})y_t - \sigma\frac{G}{C}(1 + \xi\widehat{G})g_t - (\varphi + 1)a_t \tag{32}$$

Substituting (32) into (30) with "gap" variable expression, which is defined by the difference between current and natural levels of variable, I provide the modified version of New Keynesian Phillips Curve (NKPC):

$$\pi_t = \kappa(\lambda_y\widehat{y_t} - \lambda_g\widehat{g_t}) + \beta E_t\pi_{t+1} - \lambda_a a_t \tag{33}$$

where $\widehat{x_t} \equiv x_t - x_t^n$ for any arbitrary endogenous variable x_t, $\lambda_y = (\varphi + \sigma\frac{Y}{C})$, $\lambda_g = \sigma\frac{G}{C}(1+\xi\widehat{G})$, and $\lambda_a = \sigma\frac{G}{C}\xi\widehat{G}\left[\frac{1}{Y}\left(\frac{C\phi}{\sigma} + G\right) + \frac{\phi}{\varphi}\right]^{-1}(1+\frac{1}{\varphi})$. y_t^n and g_t^n are derived from the social planner's problem in an efficient market environment:

$$y_t^n = (\varphi + \sigma\frac{Y}{C})^{-1}\left[\sigma\frac{G}{C}g_t^n + (\varphi+1)a_t\right] \tag{34}$$

$$g_t^n = \left[\frac{1}{Y}(\frac{C\phi}{\sigma} + G) + \frac{\phi}{\varphi}\right]^{-1}(1 + \frac{1}{\varphi})a_t \tag{35}$$

Detailed calculation of (34) and (35) is provided in a technical appendix. Note that as ξ goes to zero, (33) becomes a benchmark NKPC with government spending without cost push shock, since λ_a converges to zero. But with any value of ξ, the real adjustment cost exists and obviously affects on the inflation dynamics through cost push shock. As ξ increases, λ_a increases, and the trade-off of NKPC is worsened. The other channel of the effect of $\xi\widehat{G}$ is captured in λ_g, the coefficient of $\widehat{g_t}$. As ξ goes up, the amount of λ_g increases, which creates a steeper slope of NKPC. This means the larger trade-off between inflation and government spending gap in the curve. Furthermore, the sign of λ_g is determined by $\widehat{G}$. λ_g is positive if $\widehat{G}$ is positive, which means that $G > G^n$, implying that the steady state level of government spending is larger than the natural level of the spending. This can be interpreted as a boom. In this situation, public spending gap is negatively related with inflation. If $G < \widehat{G}$, a possible recession, λ_g is negative, and the public spending gap is positively related with the inflation. In either case, if a policy maker does not recognizes the existence of $\xi\widehat{G}$ term and thus naively perceived the parameter value λ_g, he should underestimate the trade-off between inflation and government spending gap since $\lambda_{g,0}$, the so called naive parameter, is smaller than the real value of λ_g. This underestimated parameter can possibly make the policy maker overshoot policy targets and thus create an unnecessary distortions in the economy. Monetary policy rule is determined separately. The log-linearized version of benchmark Taylor rule (24) is calculated by

$$r_t = r + \gamma_\pi \pi_t + \gamma_y \widehat{y_t} \tag{36}$$

Looking at (36), the log-linearized value of interest rate should be determined by the log deviated level of inflation rate and the output gap.

Another important macroeconomic equation is a so called IS relation, which can be obtained by log-linearizing the first order necessary condition of household's problem, (10), substituting economy wide resource constraint into it to replace c_t with y_t and g_t, and using (34) and (35) to express the log-linearized version of (10) with gap variables. It is derived by

$$\widehat{y_t} - \eta_g \widehat{g_t} = -\frac{C}{Y}\frac{1}{\sigma}(r_t - E_t\pi_{t+1}) + E_t\widehat{y_{t+1}} - \eta_g E_t\widehat{g_{t+1}} + \eta_{g,n} E_t \Delta g^n_{t+1} + \eta_a(E_t a_{t+1} - a_t) \tag{37}$$

where

$$\begin{aligned}
\eta_g &= \frac{G}{Y}(1+\xi\widehat{G}) \\
\eta_{g,n} &= \left(\varphi + \sigma\frac{Y}{C}\right)^{-1}\left(\sigma\frac{G}{C}(1+\xi\widehat{G})\right) \\
\eta_a &= \left[\frac{G}{C}(1+\xi\widehat{G})\left(\frac{1}{Y}(\frac{C\phi}{\sigma}+G)+\frac{\phi}{\varphi}\right)^{-1}\left(1+\frac{1}{\varphi}\right) - \left(\varphi+\sigma\frac{Y}{C}\right)^{-1}(\varphi+1)\right]
\end{aligned}$$

and $\Delta g^n_{t+1} = g^n_{t+1} - g^n_t$. Detailed process of derivation is provided in the technical appendix. (37) indicates that all three parameters η_g, $\eta_{g,n}$, and η_a are affected by $\xi\widehat{G}$ in some extents. As ξ increases, values of three parameters also increase, which induce a steeper slope of IS relation. Especially η_a increases with the higher value of ξ, it worsens the trade-off of IS relation. This exacerbated trade-off between variables is clearly captured the amount of $\xi\widehat{G}$, and without $\xi\widehat{G}$, the IS relation obviously comes back to the benchmark case.

Committee of two economic policy authorities simultaneously choose the optimal set

$\{\pi_t, \widehat{y}_t, \widehat{g}_t, r_t\}_{t\geq 0}$ subject to (33), (36), (37) along with $\{y_t^n, g_t^n\}_{t\geq 0}$ that are defined by (34) and (35), and the stochastic process, (29), given $\{\pi_{-1}, y_{-1}, g_{-1}, r_{-1}\}$. To solve this problem, I need to construct a Ramsey policy problem.

4.2 Linear Quadratic Welfare Measure

I follow Benigno & Woodford (2012) and Woodford (2003) to formulate a linear-quadratic (LQ) welfare loss function from the second order approximation to the utility function of representative household, (1), and use it as an objective of stabilization policy. As discussed in Walsh (2010), Galí (2008), and Demirel (2012), LQ welfare loss function has some merits. It not only guarantees an existence of local maximum under convexity assumption and an appropriate set of parameters, but also it provides an advantage of easiness to assess various types of alternative policy regimes measured in terms of social welfare criterion. Approximating to (1) and the economy wide resource constraint gives a detail of welfare criterion, $\mathbb{W}$

$$\mathbb{W}_t = -\frac{1}{2}\left[\pi_t^2 + \left(\frac{C^2+(1-\sigma)}{Y}\right)c_t^2 + (1-Y)y_t^2 + \left(\frac{\xi\widehat{G}+\xi G^2}{Y}\right)g_t^2 + \varphi l_t^2 + y_t a_t + (G\xi\widehat{G})g_t\right] \quad (38)$$

(38) is called ”naive” LQ welfare loss function according to Benigno & Woodford (2012), since the last term is linear, that prevents accurate calculation of economy wide welfare loss because the purpose of LQ function is to capture overall level of variance of key macroeconomic variables. Another reason why it is not the best criterion for the welfare measure is that it also contains non-policy choice variables, such as c_t and l_t, and these variables are not much helpful for policy analysis. Substituting two more relations $c_t = \frac{Y}{C}y_t - (1_\xi\widehat{G})\frac{G}{Y}g_t$ and $l_t = y_t - a_t$, one can eliminate those two non-policy selectable variables from $\mathbb{W}$. Therefore, rewriting (38) only in purely quadratic terms gives a clearer version of the loss function:

$$\mathbb{W}_t = -\frac{1}{2}\left[\pi_t^2 + \Theta_t y_t^2 + \Theta_g g_t^2 - \Theta_{y,g}y_t g_t + 2(1-\varphi)y_t a_t\right] \quad (39)$$

where $\Theta_y = \left[\left(\frac{C^2+(1-\sigma)}{Y}\right) + Y + \varphi - 1\right]$, $\Theta_g = \left[\left((1+\xi\widehat{G})\frac{G}{C}\right)^2\left(\frac{1+\xi\widehat{G}+\xi G^2+\phi}{Y}\right)\right]$, and $\Theta_{y,g} = \left[2\frac{YG}{C^2}(1+\xi\widehat{G})\right]$. Note that Θ_g and $\Theta_{y,g}$ contain $\xi\widehat{G}$ with positive signs. If ξ goes up, Θ_g and $\Theta_{y,g}$ clearly increase while Θ_y remains unchanged. This asymmetric changes of parameters influences the relative importance of policy variables in the welfare loss function. Assuming that (39) is an objective for the policy maker, relatively increased weights on g_t^2 and $y_t g_t$ terms make the policy maker lean more into the government spending variable. This means that, remembering that the increased value of ξ means the amplified penalty of the government spending spread on the economy, the policy maker perceives that with the increase ξ the economy will lose more welfare gains from government spending part. This results in an ineffectiveness of fiscal policy with higher level of ξ.

4.3 Optimal Policy Problem

A Ramsey problem using LQ approximation is defined by a maximization of the sequence of (38) subject to (33) and (37). The choice set is $\{\pi_t, y_t, g_t\}_{t\geq 0}$. r_t is automatically determined sequentially by (36).

$$max_{\pi_t,y_t,g_t} E_0 \sum_{t=0}^{\infty} \beta^t \mathcal{L}_t \tag{40}$$

where the formulated Lagrangian equation is given by

$$\begin{aligned} \mathcal{L}_t = \mathbb{W}_t &+ \chi_{1,t}\left(\kappa(\lambda_y \widehat{y_t} - \lambda_g \widehat{g_t}) + \beta E_t \pi_{t+1} - \pi_t\right) \\ &+ \chi_{2,t}\left(-\frac{C}{Y}\frac{1}{\sigma}(r_t - E_t\pi_{t+1}) + E_t\widehat{y_{t+1}} - \eta_g E_t \widehat{g_{t+1}} + \eta_{g,n} E_t \Delta g_{t+1}^n + \eta_a(E_t a_{t+1} - a_t) - \widehat{y_t} - \eta_g \widehat{g_t}\right) \end{aligned} \tag{41}$$

and $\chi_{1,t}$ and $\chi_{2,t}$ are Lagrangian multipliers or shadow prices for NKPC and IS curve, respectively.

4.4 Case of Discretion

In the case of full discretion, policy maker encounters a separate policy objective each period, and choose variables independent of past or future policy regimes. The optimal policy problem under discretion is then modified by

$$max_{\pi_t,y_t,g_t} \left[\mathbb{W}_t + D_{w,t} + \chi_{1,t}^d\left(\kappa(\lambda_y \widehat{y_t} - \lambda_g \widehat{g_t}) - \pi_t + D_{1,t}\right) + \chi_{2,t}^d\left(-\widehat{y_t} + \eta_g \widehat{g_t} - \eta_a a_t + D_{2,t}\right)\right] \tag{42}$$

where $\chi^d_{1,t}$ and $\chi^d_{2,t}$ are the discretion-specific shadow prices, and taking $D_{w,t}$, $D_{1,t}$ and $D_{2,t}$ as given, where $D_{w,t} = \sum_{s=1}^{\infty} \mathbb{W}_{t+s}$, $D_{1,t} = E_t[\beta\pi_{t+1} - \lambda_a a_t]$, and $D_{2,t} = E_t\left[-\frac{C}{Y}\frac{1}{\sigma}\pi_{t+1} + \widehat{y_{t+1}} - \eta_g \widehat{g_{t+1}} + \eta_{g,n}\Delta g^n_{t+1} + \eta_a(a_{t+1} - a_t)\right]$. First order conditions are derived as following:

$$
\begin{aligned}
-\pi_t - \chi^d_{1,t} &= 0 && (43)\\
-\Theta_y y_t - \Theta_{y,g} g_t + 2(1-\varphi)a_t + \kappa\lambda_y \chi^d_{1,t} - \chi^d_{2,t} &= 0 && (44)\\
-\Theta_g g_t - \Theta_{y,g} y_t - \kappa\lambda_g \chi^d_{1,t} + \eta_g \chi^d_{2,t} &= 0 && (45)
\end{aligned}
$$

From the equation (43), ene can find that a policy inconsistency problem can be arisen. Above equations are reduced to the one to express the Ramsey equilibrium level of π_t in terms of y_t, g_t, and a_t in this full discretion case:

$$\pi_t = \left(1 - \frac{1}{\eta_g}\right)^{-1} [(\Theta_{y,g} + \Theta_y)y_t - (\Theta_{y,g} + \Theta_g)g_t + 2(1-\varphi)a_t] \quad (46)$$

According to (46), regardless of the past history of the policy regimes or future expectation, the monetary policy maker will adopt the notion of information on the fiscal policy decisions as given and refresh its policy tools at each period. Moreover, since parameters of η_g, $\Theta_{y,g}$ and Θ_g contain $\xi\widehat{G}$, the level of ξ makes its own effect on the result of π_t in this discretion case. The overall effect of ξ is captured by the first two terms of (46), $\left(1 - \frac{1}{\eta_g}\right)^{-1}[(\Theta_{y,g} + \Theta_y)y_t - (\Theta_{y,g} + \Theta_g)g_t]$. Effect of an additional increase in ξ on π_t in (46) can be calculated by total derivation of π_t with respect to ξ. It is derived by

$$\frac{d\pi_t}{d\xi} = \left(1 - \frac{1}{\eta_g}\right)^{-1}\left[(\Theta_{y,g} + \Theta_y)(2\widehat{G}\frac{YG}{C^2}) - (\Theta_{y,g} + \Theta_g)(2(1+\xi\widehat{G})(\frac{1+\xi\widehat{G}\xi G^2 + \phi}{Y})\frac{G}{C}\widehat{G} + ((1+\xi\widehat{G})^2(\frac{\widehat{G} + G^2}{Y}))\right]$$

The above equation shows the effect of ξ on the equilibrium inflation level, π_t. If the first term inside the second parenthesis is larger than the second term, $\frac{d\pi_t}{d\xi}$ is positive, which can be interpreted that the additional increase in ξ can positively affect on the inflation rate, and thus on the interest rate through (36). Therefore, the level of ξ is a key to the change of interest rate in discretion case.

4.5 Case of Commitment

Problem of (40) and (41) can be directly described as a full commitment case. The solutions of the maximization problem can be calculated by the following first order conditions:

$$-\pi_t - \chi_{1,t} + \beta^{-1}\chi_{1,t-1} = 0 \tag{47}$$

$$-\Theta_y y_t - \Theta y, g g_t + 2(1-\varphi)a_t + \kappa\lambda_y\chi_{1,t} - \chi_{2,t} + \beta^{-1}\chi_{2,t-1} = 0 \tag{48}$$

$$-\Theta_g g_t - \Theta y, g y_t - \kappa\lambda_g\chi_{1,t} + \eta_g\chi_{2,t} + \beta^{-1}\eta_g\chi_{2,t-1} = 0 \tag{49}$$

The above conditions can be reduced to one expression for the π_t, in terms of current levels and discounted past levels of output, public spending, and the stochastic process deviations:

$$\pi_t = \frac{1}{\kappa(\lambda_y - \lambda_g)}\left[\left(\frac{\Theta_{y,g}}{\eta_g} + \Theta_y\right)(y_t - \beta^{-1}y_{t-1}) - \left(\frac{\Theta_y}{\eta_g} + \Theta_{y,g}\right)(g_t - \beta^{-1}g_{t-1}) + 2(1-\varphi)(a_t - \beta^{-1}a_{t-1})\right] \tag{50}$$

In the commitment case, unlike the discretion strategy, the effect of variables on π_t is one time lagged with discounting factor β. While policy makers in discretion case should not believe that his policy decision affects on future economic changes since the inflation is purely independent of past or future period, the policy makers in commitment case should take into account the lagged effect of variables. In addition, note that coefficients on the lagged values of y_t and g_t are slightly different from the discretion case. While in discretion case coefficients are weighted by $\left(1 - \frac{1}{\eta_g}\right)^{-1}$, which includes $\widehat{G}$ and is used in IS relation, a commitment case variables are weighted by $\frac{1}{\kappa(\lambda_y - \lambda_g)}$, which also includes $\widehat{G}$ but it is used in NKPC. Moreover, the effect of the level of ξ can be observed as in the discretion case. Taking total derivative of π_t with respect to ξ shows the similar result with the discretion case, arguing the importance of ξ as a determinant of the level of r_t, the policy interest rate.

5 Quantitative Analysis

In this section, I compute the numerical values of solutions from the discretion and commitment cases, and analyze the statistical characteristics of them. Furthermore, I test some candidates of Taylor rule with different weights on inflation and output stabilization under LQ welfare loss criteria.

I compare those policy regimes to find the optimal monetary policy among the candidates.

5.1 Parameterization

In order to numerically compute the impulse responses of the objective function under optimal commitment stabilization policy to the positive productivity shock, I obtain the structural parameters of the described model. Table 1 shows the benchmark values of the parameters. First of all, to illustrate the macroeconomic properties of developing or emerging market economies, I adopt some of the parameters from papers, such as Devereux et al. (2006) or Demirel (2010), which consider that kinds of characterized market imperfections. Since the many of emerging market economies have experienced relatively high interest rate for targeting, I modify the time preference parameter β as 0.985 so that the risk-free interest rate, R, can be about 6%. I follow Demirel (2010) to set up intratemporal elasticity between private and public goods as 2, and I assume inverse elasticity of labor supply to be unity following Devereux et al. (2006). While the correct level of degree of price stickiness is still in debate between leading papers in the area of policy discussion in emerging market economies, it is assumed to be 0.67, which is generally accepted in New Keynesian literature such as Sbordone (2002) which estimates the value of price stickiness under specific modeling. The paper also gives a reasonable parameter value of the inverse of labor supply elasticity, which is assumed to be one. Inter-temporal elasticity of substitution between differentiated final goods is set to be 11, which makes the markup revenue for each individual monopolistic competitive firm be 0.1. The degree of severity of the government spending spread,ξ, is assumed to be positive and adjusted such that the system of equations have a unique solution without loss of generality since the relative scale of the degree parameter is the only curiosity in this study. For example, ξ converging to zero means that the economy is approaching to the level where less effect of the imperfect infrastructural development is on the economy, in relative terms, by improving some exogenous factors such as tax system or political transparency. Relatively higher level of ξ gives larger effect of the adjustment cost to the economy that means there will be worse condition that amplify the effect, and thus have a long way to go to the ideal level of public expenditures. The baseline value of ξ is varied from 0 to 10. Steady state values of macroeconomic variables such as C, Y, L, and G are guessed at first step and calculated analytically by Matlab. The stochastic process is defined following Demirel (2010), which sets up the autoregressive parameter and productivity shocks such that the model calibrates the results of Adam & Billi (2008) and the history of United States volatility of inflation. The remains of the parameterization are policy parameters, γ_π and γ_y. They are set to be an appropriate level such that the model has a unique local maximum, and modified in the following sections to assess alternative policy regimes. The benchmark value of γ_π is 1.5 to 5, and γ_y is varied from 0.125 to 1.5.

5.2 Procyclity of Macroeconomic Policies

Figure 1 show a change of correlations under commitment. [2] Figure 1 represents the correlations between output and government spending as ξ changes from 0 to 10, and Figure 2 shows a change of correlations between output and interest rate as ξ changes from 0 to 10. Observing that both correlations close to absolute value 1 as ξ diverges, Figure 1 and 2 clearly show that higher level of procyclity of fiscal and monetary policy are conducted as ξ, the degree of the effect of imperfect infrastructural development on the economy, increases. Furthermore, one can also find that the change of correlation between output and government spending is little larger than that between output and interest rate, which means that fiscal part of the economy is more vulnerable to the change of ξ. This result is obvious because the real friction in the model is created from the inability of the economy to muffle the gap between current and natural level of public spending, and the higher degree of the friction deepens the ineffectiveness of fiscal policy. Therefore, fiscal policy is relatively more sensitive to the change of ξ. In Figure 1, there is a kinked period of the curve in which correlations around $\xi = 1$ and $\xi = 2$ are lower than a correlation at $\xi = 0$. This curious result can be interpreted as a situation where the positive effect of ξ is so negligible that it is easily overwhelmed by the other factors moving correlations to the opposite direction.

5.3 Impulse Response: Discretion

Figure 3 shows impulse responses of the model under discretion to 1% positive productivity shock with or without the real adjustment cost, ξ. Table 2 shows theoretical moments of key macroeconomic variables under these impulse responses. From these results, one can firstly find that regardless of the level of ξ, there always exist a procyclical fiscal and monetary policies.

[2] Change of correlation under discretion cannot be calculated because in discretion case, correlation between any two variables is always unity, which means that every variable is perfectly correlated with each other so that the statistic gives nothing meaningful implication.

However, as shown in the precious subsection, the degree of procyclity of policies are deepened by ξ. Moreover, as Table 2 represents, higher level of ξ generates more volatility in every part of the economy. The positive cost push shock is amplified by higher value of ξ in (33), and thus the policy maker, which has only two policy tools in present period, $\widehat{y_t}$ and $\widehat{g_t}$, has to sacrifice the higher level of business cycle fluctuations in order to stabilize the economic variables. Therefore, in discretion policy regime with higher level of ξ, procyclity in fiscal and monetary policy tends to be high, and the economy has also high level of volatility.

5.4 Impulse Response: Commitment

Figure 4 shows the impulse responses of key variables to 1% positive productivity shock under commitment with variation of ξ, from 0 to 10. Table 3 shows theoretical moments of the key variables in the impulse response under commitment. Comparing two extreme cases, zero level of ξ and relatively high ($\xi = 10$) level of the cost, as already shown in Figure 1 and 2, fiscal and monetary policies tend to be more procyclical when ξ is high. Moreover, according to Table 3, volatility of variables significantly increase as ξ increases. Therefore, the effective imperfect infrastructure and the economic volatility have a positive relationship in commitment case. Contrast to the discretion case, policy makers manipulate current level of output gap and government spending gap, $\widehat{y_t}$ and $\widehat{g_t}$, they also use the future expectation of inflation rate as a policy instrument. As output goes up after positive productivity shock, monetary authority can effectively make an inflation by decreasing interest rate as fiscal authority increases spending as a result of procyclical movement, and this overshooting inflation can improve the trade-off between inflation and output stabilization encountered by policy makers. Therefore, future inflation rate and the other variables are now linked to the current ones by policy measure. As long as the inflation is remained, output has a serial correlation for several periods as well. The main result from the simulation is that, the higher level of ξ worsens the trade-off between inflation and output stabilization schemes. While it creates higher level of volatility, it also generates longer periods of lagged effect of policy instruments on the economy. Policy makers must overshoot inflation to stabilize the worsened trade-off, and thus they experience higher level of output at the beginning stage and longer discouraged period.

5.5 Discretion versus Commitment

Figure 5 shows a comparison of impulse responses under discretion and commitment. When there is a high degree of imperfect infrastructural development effect on the economy ($\xi = 10$), both discretion and commitment cases clearly show that the fiscal and monetary policies follow procyclical behavior. Discretion case has no serial correlation because the only available policy instruments in this case is current output gap, manipulated by fiscal policy. But in commitment case there is future expectation of inflation as an additional instrument for policy maker. This variability of policy tools makes a main difference between discretion and commitment cases of impulse responses. Under discretion, in response to the rising output due to the positive productivity shock, the policy maker has to use fiscal policy to stabilize it because it is the only source in the suboptimal case. As a result, the policy maker bears severer decrease in inflation rate. In contrast, under commitment case, policy maker can effectively make an deflation in response to the output increase at the beginning stage since they can use both output gap and future inflation rate expectation. This scheme gives an advantage of reducing inflation volatility, but it amplifies the procyclical trend of fiscal policy. The result of this different policy instrument between discretion and commitment cases can be found in the last four rows of Table 2 and 3. While policy regimes under discretion yield higher level of inflation and interest rate, the economy under commitment bears relatively higher level of output and government spending.

5.6 Alternative Monetary Policy Discussion

It would be interesting to compare different monetary policy regimes to find the optimal one. To do this, I change policy parameter values γ_π and γ_y in the standard Taylor rule (36) under the existence of $\xi = 10$. I follow Galí (2008) in deciding those values. The benchmark value of γ_π equals 1.5, following Taylor (1993), but γ_y is set to unity, which is higher than the suggested value in the paper. First test is compare the benchmark Taylor rule with aggressive inflation stabilization targeting rule, with $\gamma_\pi = 5$ while γ_y unchanged. Next I compare the benchmark Taylor rule with the original Taylor rule given in Taylor (1993), which is an approximation to the policy rule of Federal Reserve Board during Greenspan era. Table 4 represents the result of standard deviations of the benchmark and the alternative policy regimes. First column shows standard deviations of four macroeconomic variables with benchmark policy parameters. Second and third columns show the aggressive inflation stabilization targeting Taylor rule and the original Taylor rule with relatively weak motive on the output gap stabilization, respectively.

First of all, according to Table 4, comparing first column to the second one, the benchmark Taylor rule clearly generates less volatility than the aggressive inflation targeting rule. Figure 6 represents impulse responses of these two different cases of Taylor rule. While both regimes have procyclical fiscal and monetary policies under pressure of $\xi = 10$, the trade-off between inflation and output gap stabilization is much more improved with standard Taylor rule. If monetary authority has too much weight on inflation targeting, say $\gamma_\pi = 5$, it must bear large drop in interest rate to accomplish almost the same level of inflation to stabilize output increases. It also amplifies the procylity of fiscal policy with higher level of volatility. The aggressive inflation stabilizing rule reaches at a very little success on stabilizing inflation, but experiences huge increase in volatilities of output, government spending, and interest rate. This clearly shows the worsened trade-off between inflation and output stabilization faced by monetary policy maker.

Second, weak motive on the output gap stabilization also suboptimal compared to the benchmark Taylor rule which has higher policy parameter value on γ_y. Similar to the previous result, Taylor rule with weak motive on output stabilization accomplishes in stabilizing inflation rate but the difference from the benchmark one is very modicum. On the other hand, it bears much higher volatilities in remained variables. Figure 7 shows impulse responses of both cases to 1% positive productivity shock. While they achieve almost the same level of deflation in response to the increase in output, the weak motive rule must give up lower level of interest rate and higher level of government spending. Even with that exacerbated trade-off, the weak motive rule creates longer serial correlation periods with negative value of output as a result of the deflationary policy.

6 Concluding Remarks

I build a closed economy new Keynesian model with sticky price, monopolistic competition, and a real friction in government spending gap. The level of the public spending gap positively affects on the procyclity of fiscal and monetary policy by worsening trade-off between inflation and output stabilization faced by policy makers. As a result, if the degree of the severity of the government expenditure spread is relatively high, captured by the parameter value ξ, the fiscal and monetary policy tend to be more procyclical, and the economy has higher volatilities in every key macroeconomic variables. In both discretion and commitment cases of policy regime, higher level of imperfect infrastructure worsens the trade-off, and generates higher volatility in the economy. Under discretion policy regime, unlike the commitment case, the policy makers can only handle the current level of government spending and interest rate to stabilize the changed output level due to the productivity shock, so that they must bear higher volatility in inflation and interest rate. Under commitment, the policy makers can use future expectation of inflation as an additional policy instruments, so that they can effectively adjust deflation to stabilize output increase, but they give up government spending fluctuation due to the worsened procyclity of the public expenditure. Comparing alternative Taylor rules, I find that the benchmark Taylor rule is better policy choice than weak motive on output stabilization rule or too aggressive inflation targeting rule.

There are several notable limitations in this paper. First, the model assumes that the fiscal authority collects taxes only in lump sum fashion to finance its spending. But in reality, as mentioned by Tanzi & Zee (2000), most developing countries experience the trend that large portion of their tax structure is consumption or income taxes which are known as distortionary. Therefore, it must be worthwhile to look carefully at the change in the model if any kind of distortionary tax is introduced. Second, since many developing or emerging market economies are heavily dependent of international trade and foreign capital flows, opening up the international dimensions of the model should be interesting and more than encouraging. While monetary policies of most developing countries are influenced by the exchange rate in some extent, introducing exchange rate pegging option in the group of alternative policy candidates and comparing it with the closed economy version Taylor rule maybe also interesting. As Galí & Monacelli (2008) tries for the case of monetary union in Europe, an special case of developing countries can be treated in open economy version of model. Third, as Frankel (2011) points out, besides the imperfect infrastructural development and heavy dependence on international trades, another characterized fact about developing countries can be substantial in policy decision making such that the fact which they still suffer from political instability or central bank independence problem. In many of those countries, central bank is under pressure of fiscal or other political institutions and thus the central bank cannot optimally choose its own policy regime independently. Related to this topic, inconsistency problem of discretion is still common across the countries. The model of this paper ignores those realities and they should be reconsidered. Another interesting possible future work is recently changing trend of the procyclity in developing economies. According to Frankel et al. (2011), during the last decade, 24 out 73 developing countries made a historic shift from procyclical trend to countercyclical tendency of their policy regimes. This should be related with the previously mentioned limitation of the model such as the international dimension of policy decision making, since the most of those countries have experienced an opening of their financial markets or significant change in international capital flows in the recent decade.

A Efficient Level Equilibrium

In order to have natural rates of output and government spending as a log-linearized form, one needs to solve a competitive equilibrium problem under complete market environment. A social planner's problem is given by the maximization of the utility function, (1), such that the economy-wide budget constraint,

$$C_t + G_t = A_t L_t \tag{51}$$

First order necessary conditions are calculated and log-linearized by

$$\varphi l_t - a_t = -\sigma c_t = -\phi g_t \tag{52}$$

Note that the second equality comes from the efficient level equilibrium condition that marginal utility of private consumption should be equal to marginal utility of public consumption. The economy-wide budget constraint is also log-linearized by

$$a_t + l_t = \frac{C}{Y} c_t + \frac{G}{Y} g_t \tag{53}$$

Combining (54) and (55) to remove l_t and c_t and express g_t in terms of a_t, the exogenous variable, one can obtain the natural level of government spending given by

$$g_t = \left[\frac{1}{Y} \left(\frac{C\phi}{\sigma} + G \right) + \frac{\phi}{\varphi} \right]^{-1} \left(1 + \frac{1}{\varphi}\right) a_t \tag{54}$$

which corresponds to (35).

To achieve a efficient level of output, y_t^n, setting (32) to be zero, which means that in the efficient level the real marginal cost should be zero since there is neither price rigidity nor imperfect competition. And substituting (56) into the modified equation, one can express y_t in terms of a_t and the other parameters.

$$y_t = (\varphi + \sigma\frac{Y}{C})^{-1}\left[\sigma\frac{G}{C}g_t^n + (\varphi+1)a_t\right] \tag{55}$$

which corresponds to (34).

B Derivation of IS relation

In this part, I show the detailed calculation of deriving IS equation. Log-linearizing the Euler equation (10) gives a log deviation version of relationship between consumption stream and inflation changes:

$$-\sigma c_t = (r_t - \pi_{t+1}) - \sigma c_{t+1} \tag{56}$$

To replace c_t and c_{t+1} with terms of y_t and g_t, one needs to log-linearize economy wide resource constraint, $Y_t = C_t + G_t + \frac{\xi}{2}(G_t - G_t^n)^2$ and rewrite it with the expression of c_t,

$$c_t = \frac{Y}{C}y_t + \frac{G}{C}(1+\xi\widehat{G})g_t \tag{57}$$

Substituting (59) into (58) gives an expression for y_t, g_t, r_t, and π_{t+1},

$$y_t - \frac{G}{Y}(1+\xi\widehat{G})g_t = -\frac{C}{\sigma Y}(r_t - \pi_{t+1}) + y_{t+1} + \frac{G}{Y}(1+\xi\widehat{G})g_{t+1} \tag{58}$$

The remaining part is to express (6) with "gap" variables, which is defined by $\widehat{x_t} = x_t - x_t^n$ for any arbitrary variable x. Substituting definitions of y_t^n and g_t^n from (34) and (35) into (60) provides an expression for $\widehat{y_t}$ and $\widehat{g_t}$:

$$\begin{aligned}
&\widehat{y_t} + (\varphi + \sigma\frac{Y}{C})^{-1}\left[\sigma\frac{G}{Y}(1+\xi\widehat{G})\right]g_t^n + (\varphi+\sigma\frac{Y}{C})^{-1}(\varphi+1)a_t - \frac{G}{Y}(1+\xi\widehat{G})\widehat{g_t} \\
&- \frac{G}{Y}(1+\xi\widehat{G})(\frac{1}{Y}(\frac{c\phi}{\sigma}+G)+\frac{\phi}{\varphi})^{-1}(1+\frac{1}{\varphi})a_t \\
&= -\frac{1}{\sigma}\frac{C}{Y}(r_t - \pi_{t+1}) + \widehat{y_{t+1}} + (\varphi+\sigma\frac{Y}{C})^{-1}\left[\sigma\frac{G}{C}(1+\xi\widehat{G})\right]\widehat{g_{t+1}} + (\varphi+\sigma\frac{Y}{C})^{-1}(\varphi+1)a_{t+1} \\
&- \frac{G}{Y}(1+\xi\widehat{G})\widehat{g_{t+1}} - \frac{G}{Y}(1+\xi\widehat{G})(\frac{1}{Y}(\frac{C\phi}{\sigma}+G)+\frac{\phi}{\varphi})^{-1}(1+\frac{1}{\varphi})a_{t+1}
\end{aligned} \tag{59}$$

Rewriting (61) provides new Keynesian IS equation with the government spending under frictions:

$$\begin{aligned}
&\widehat{y_t} - \frac{G}{Y}(1+\xi\widehat{G})\widehat{g_t} + \frac{G}{Y}(1+\xi\widehat{G})\widehat{g_{t+1}} \\
&= -\frac{1}{\sigma}(r_t - E_t\pi_{t+1}) + \widehat{y_{t+1}} + (\varphi+\sigma\frac{Y}{C})^{-1}\left[\sigma\frac{G}{Y}(1+\xi\widehat{G})\right](g_{t+1}^n - g_t^n) \\
&- \left[\frac{G}{Y}(1+\xi\widehat{G})(\frac{1}{Y}(\frac{C\phi}{\sigma}+G)+\frac{\phi}{\varphi})^{-1}(1+\frac{1}{\varphi}) - (\varphi+\sigma\frac{Y}{C})^{-1}(\varphi+1)\right](a_{t+1}-a_t)
\end{aligned} \tag{60}$$

which corresponds to (37) with following definitions of parameters.

C Derivation of Linear-Quadratic Welfare Loss Function

In this part, I derive the second order approximation to the utility function of a representative consumer to find the appropriate value of linear-quadratic welfare loss function, shown in (38) and (39). To do this job, I use the following Taylor series expansion

$$\frac{X_t - X}{X} \simeq x_t + \frac{1}{2}x_t^2 + O(\parallel \varepsilon_a \parallel^3) \tag{61}$$

for any arbitrary endogenous variable X_t. First step is to get second order approximation to the utility function, (1). It is useful to use the knowledge of (63) and the following three additional convenient relations:

$$\sigma = -\frac{U_{CC}}{U_C}C \quad (62)$$
$$\phi = -\frac{U_{GG}}{U_G}G \quad (63)$$
$$\varphi = \frac{U_{LL}}{U_L}L \quad (64)$$

where $U_X \equiv \frac{\partial U(.)}{\partial X}$ and $U_{XX} \equiv \frac{\partial^2 U(.)}{\partial X^2}$. After second order approximation, the first term in (1) can be rewritten by

$$\begin{aligned}\frac{C_t^{1-\sigma}}{1-\sigma} &\simeq \frac{C^{1-\sigma}}{1-\sigma} + U_C C(c_t + \frac{1}{2}c_t^2) + \frac{1}{2}U_{CC}C^2 c_t^2 + O(\parallel \varepsilon_a \parallel^3) \\ &= \frac{C^{1-\sigma}}{1-\sigma} + U_C C(c_t + \frac{1}{2}(1-\sigma)c_t^2) + O(\parallel \varepsilon_a \parallel^3) \quad (65)\end{aligned}$$

The second term can be expressed in the similar way,

$$\begin{aligned}\frac{G_t^{1-\phi}}{1-\phi} &\simeq \frac{G^{1-\phi}}{1-\phi} + U_G G(g_t + \frac{1}{2}g_t^2) + \frac{1}{2}U_{GG}G^2 g_t^2 + O(\parallel \varepsilon_a \parallel^3) \\ &= \frac{G^{1-\phi}}{1-\phi} + U_G G(g_t + \frac{1}{2}(1-\phi)g_t^2) + O(\parallel \varepsilon_a \parallel^3) \\ &= \frac{G^{1-\phi}}{1-\phi} + U_C \frac{G}{C}(g_t + \frac{1}{2}(1-\phi)g_t^2) + O(\parallel \varepsilon_a \parallel^3) \quad (66)\end{aligned}$$

The last line in (68) is derived by the efficient level equilibrium condition $U_C = U_G$. The third term for labor disutility is approximated by

$$\begin{aligned}\frac{L_t^{1+\varphi}}{1+\varphi} &\simeq \frac{L^{1+\varphi}}{1+\varphi} + U_L L(l_t + \frac{1}{2}l_t^2) + \frac{1}{2}U_{LL}L^2 l_t^2 + O(\parallel \varepsilon_a \parallel^3) \\ &= \frac{L^{1+\varphi}}{1+\varphi} + U_L L(l_t + \frac{1}{2}(1+\varphi)g_t^2) + O(\parallel \varepsilon_a \parallel^3) \\ &= \frac{L^{1+\varphi}}{1+\varphi} + U_C \frac{L}{C}(l_t + \frac{1}{2}(1+\varphi)l_t^2) + O(\parallel \varepsilon_a \parallel^3) \quad (67)\end{aligned}$$

To express the last line I use the condition that the marginal rate of substitution between private consumption and labor should be equal to the marginal product of labor. Combining (67), (68), and (69), the welfare measure at time t is given by

$$V_t = U_C C\left[c_t + \frac{G}{C}g_t - \frac{L}{C}l_t + \frac{1}{2}(1-\sigma)c_t^2 + \frac{1}{2}(1-\phi)g_t^2 + \frac{1}{2}(1+\varphi)l_t^2\right] + t.i.p. + O(\| \varepsilon_a \|^3) \quad (68)$$

where $t.i.p.$ denotes "terms independent of policy." To remove the linear terms in (70) and replace l_t with other variables, I obtain the log-linearized version of the second order approximations of economy wide resource constraint, $Y_t = C_t + G_t + \frac{\xi}{2}(G_t - G_t^n)^2$ and the technology of the economy, $Y_t = A_t N_t$.

$$\begin{aligned} Yy_t + \frac{1}{2}y_t^2 &= \frac{1}{2}\pi^2 + (1+\xi\widehat{G})Gg_t + \frac{1}{2}(1+\xi\widehat{G}+\xi G^2)g_t^2 + Cc_t + \frac{1}{2}C^2c_t^2 \quad (69) \\ l_t &= y_t + \frac{1}{2}y_t^2 - y_t a_t - \frac{1}{2}l_t^2 \quad (70) \end{aligned}$$

Substituting (71) into (70) gives

$$\begin{aligned} V_t &= U_C C\left[-\frac{1}{2}\frac{1}{Y}(1+\xi\widehat{G}+\xi\widehat{G}^2)g_t^2 - \frac{1}{2}\frac{C^2}{Y}c_t^2 - \frac{G}{Y}\xi\widehat{G}g_t + \frac{1}{2}Yy_t^2 - \frac{1}{2}y_t^2 + y_t a_t + \frac{1}{2}l_t^2 + \frac{1}{2Y}(1-\sigma)c_t^2 + \frac{1}{2Y}(1-\phi \right. \\ &= U_C C\left[(\frac{C^2}{Y} + \frac{(1-\sigma)}{Y})c_t^2 + (Y-1)y_t^2 + 2y_t a_t + (-\frac{(1+\xi G\widehat{G})}{Y} + \frac{(1-\sigma)}{Y})g_t^2 - \varphi l_t^2\right] + t.i.p. + O(\| \varepsilon_a \|^3) \end{aligned}$$

which corresponds to (38).

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Table 1: Baseline Parameter Values

Symbol	Name	Estimated Value
φ	Reverse of Elasticity of Labour Supply	1
σ	Inter-temporal Elasticity of Substitution in Private Consumption	2
ϕ	Inter-temporal Elasticity of Substitution in Public Consumption	2
β	Time Discount Factor	0.985
δ	Intra-tempotal Elasticity of Substitution between Differentiated Goods	11
μ	Markup Revenue	0.1
θ	Degree of Price Stickiness	0.67
Y	Steady State Value of Y_t	0.5108
G	Steady State Value of G_t	0.9701
C	Steady State Value of C_t	0.5013
L	Steady State Value of L_t	0.4998
ξ	Degree of severeness of real friction in the government spending spread	[0, 10]
ρ	Coefficient of AR(1) process	0.9
ε^a	Standard Deviation of Productivity Shock	0.8125
γ_π	Benchmark Policy Parameter for log of Inflation	1.5
γ_y	Benchmark Policy Parameter for log of Output Gap	1
R	Policy Anchor Value of Interest Rate	6

Table 2: Theoretical Moments: With or without Real Frictions in Government Spending Difference: Discretion Case (HP filter, lambda = 1600)

Variable ($\xi = 0$)	STD. DEV.	Variance
Inflation Rate	0.6313	0.3985
Output	0.5948	0.3538
Government Spending	0.133	0.0177
Interest Rate	1.1082	1.228
Variable ($\xi = 1$)	STD. DEV.	Variance
Inflation Rate	1.1429	1.3061
Output	0.9446	0.8922
Government Spending	0.1971	0.0389
Interest Rate	1.5593	2.4315
Variable ($\xi = 10$)	STD. DEV.	Variance
Inflation Rate	5.867	34.426
Output	3.5808	12.8218
Government Spending	0.3840	0.1475
Interest Rate	6.3117	39.838

Table 3: Theoretical Moments: With or without Real Frictions in Government Spending Difference: Commitment Case (HP filter, lambda = 1600)

Variable ($\xi = 0$)	STD. DEV.	Variance
Inflation Rate	0.5911	0.3494
Output	0.5733	0.3287
Government Spending	0.1357	0.0184
Interest Rate	1.0589	1.1213
Variable ($\xi = 1$)	STD. DEV.	Variance
Inflation Rate	1.048	1.0984
Output	0.9679	0.9369
Government Spending	0.2511	0.063
Interest Rate	1.3773	1.8969
Variable ($\xi = 10$)	STD. DEV.	Variance
Inflation Rate	5.2278	27.3297
Output	5.5632	30.9496
Government Spending	1.7852	3.1870
Interest Rate	3.2923	10.8395

Table 4: Evaluation of Alternative Monetary Policies

γ_π	1.5	5	1.5
γ_y	1	1	0.125
STD(π)	5.2278	5.0515	5.2502
STD(y)	5.5632	16.9033	11.8235
STD(g)	1.7852	5.7621	3.3114
STD(r)	3.2923	9.6539	6.7227

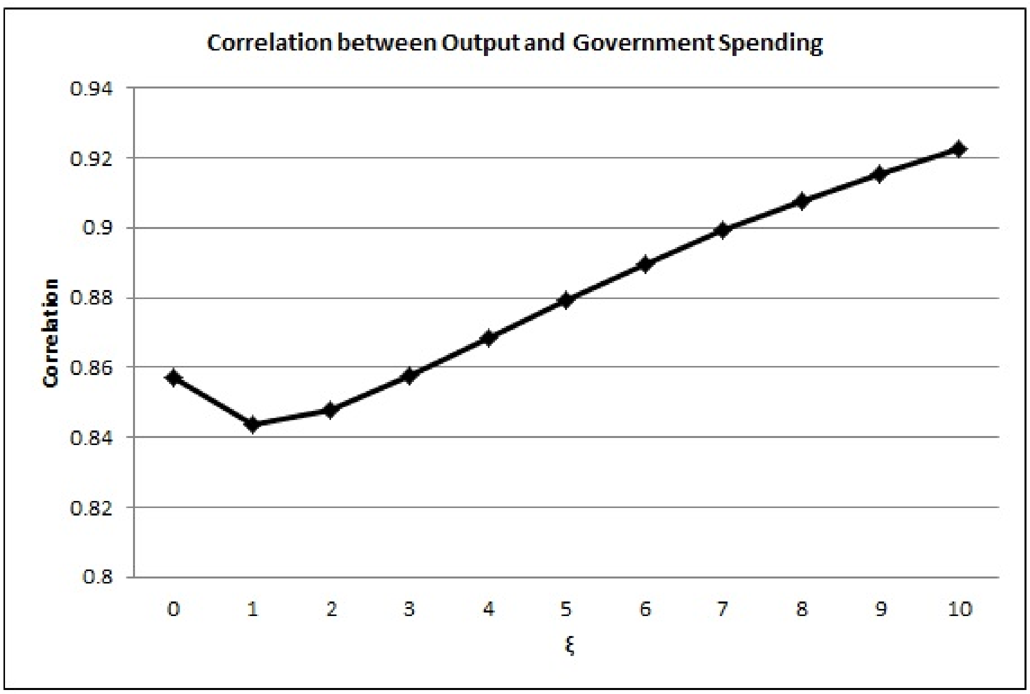

Figure 1: Change of Correlation between Output and Government Spending with respect to Change of ξ

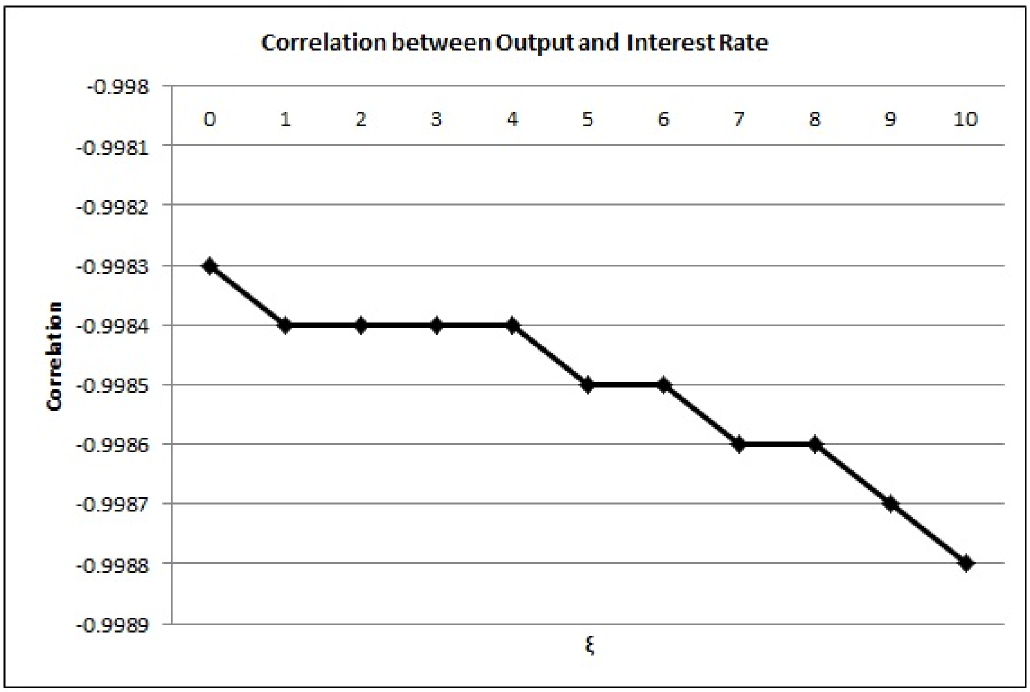

Figure 2: Change of Correlation between Output and Interest Rate with respect to Change of ξ

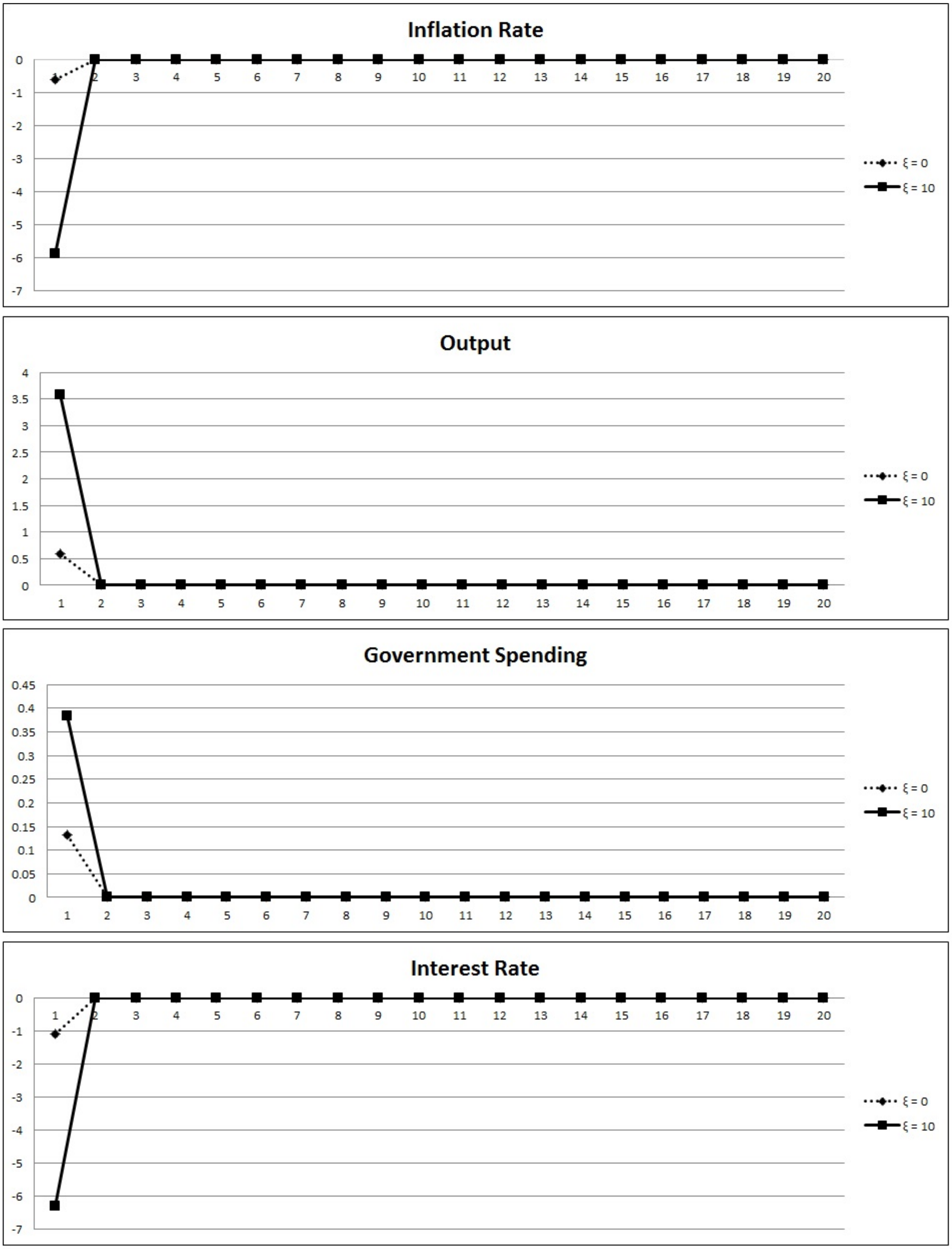

Figure 3: Impulse Responses to 1% Positive Productivity Shock under Discretion: Variation of ξ

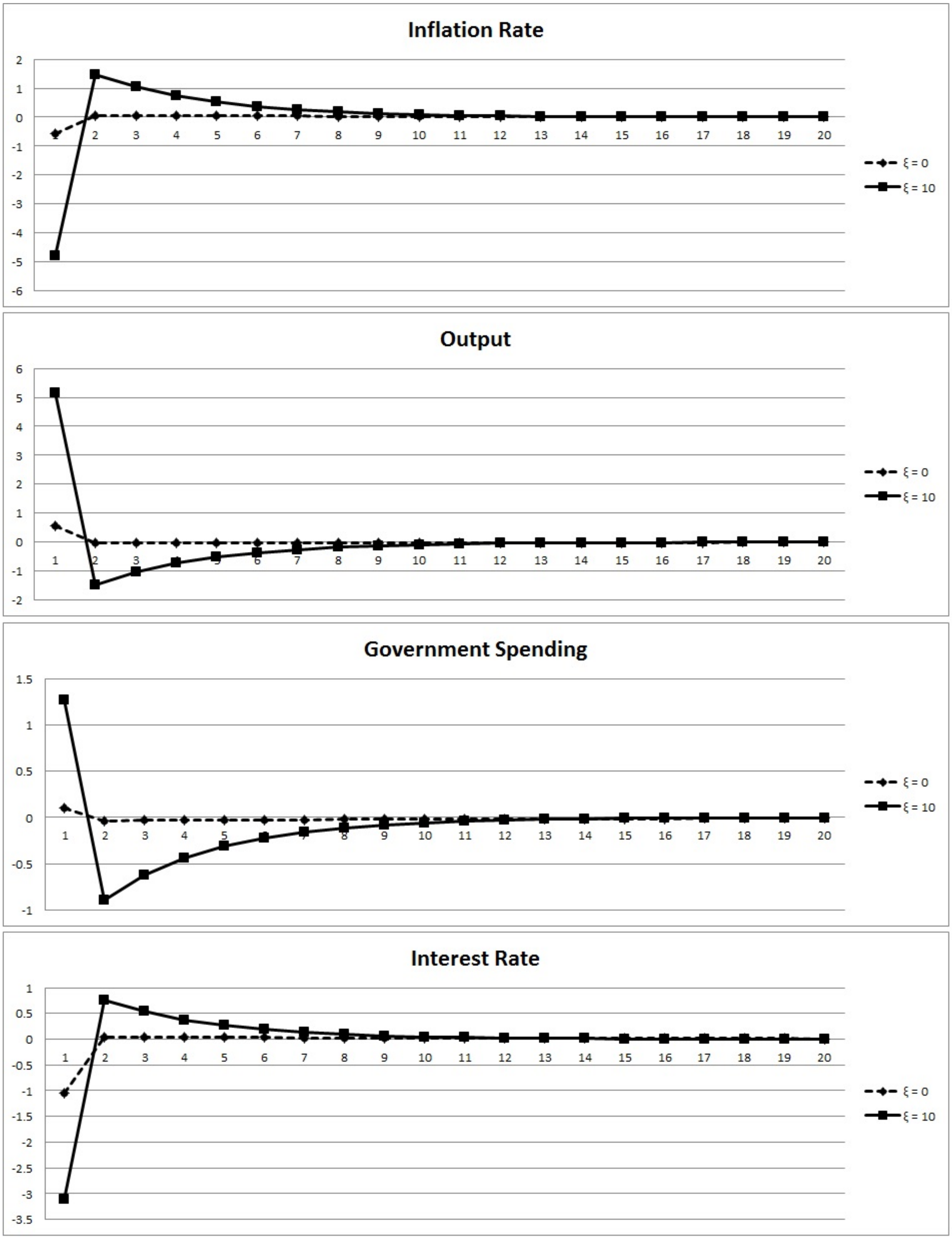

Figure 4: Impulse Response to 1% Positive Productivity Shock under Commitment: Variation of ξ

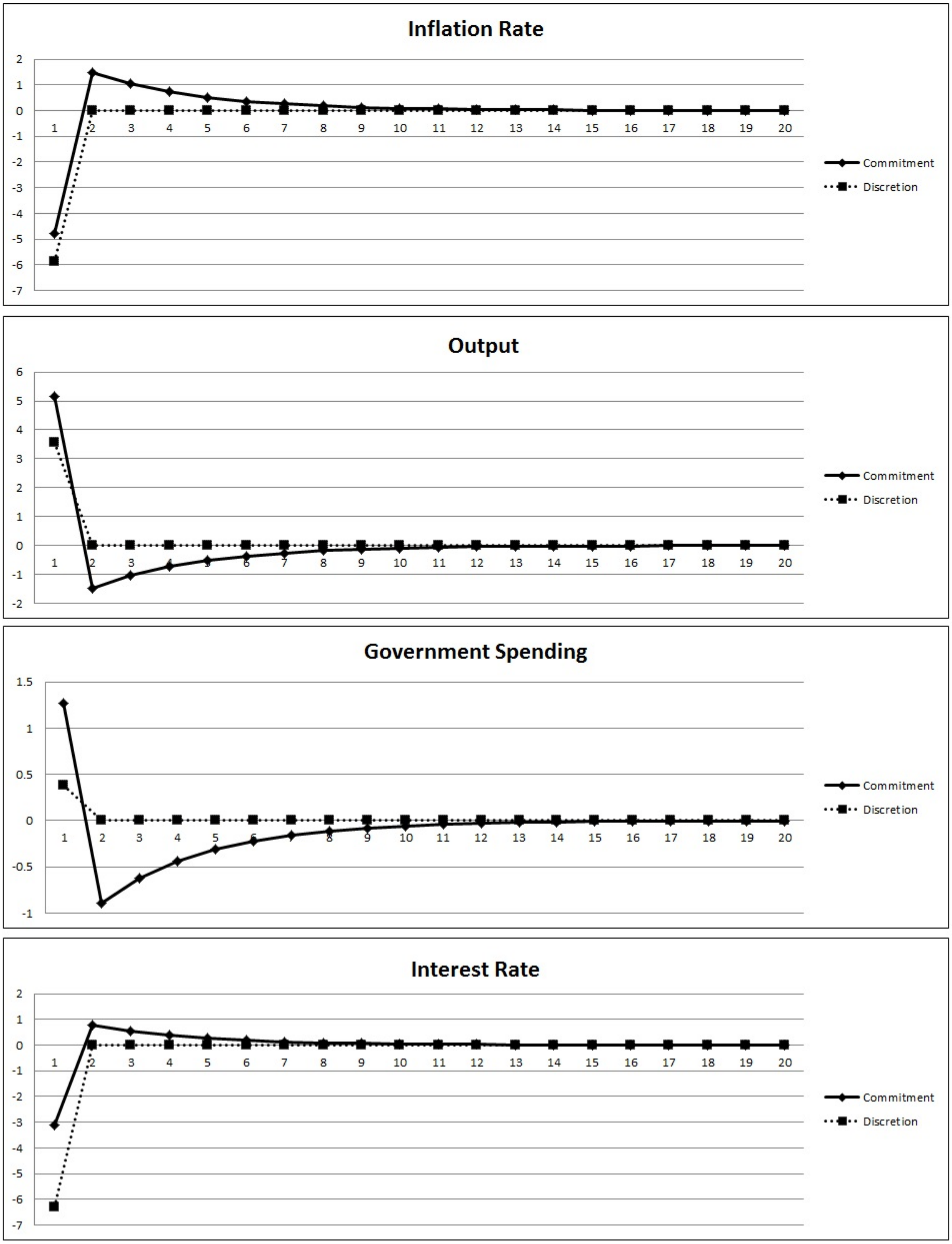

Figure 5: Impulse Response to 1% Positive Productivity Shock: Discretion vs. Commitment with $\xi = 10$

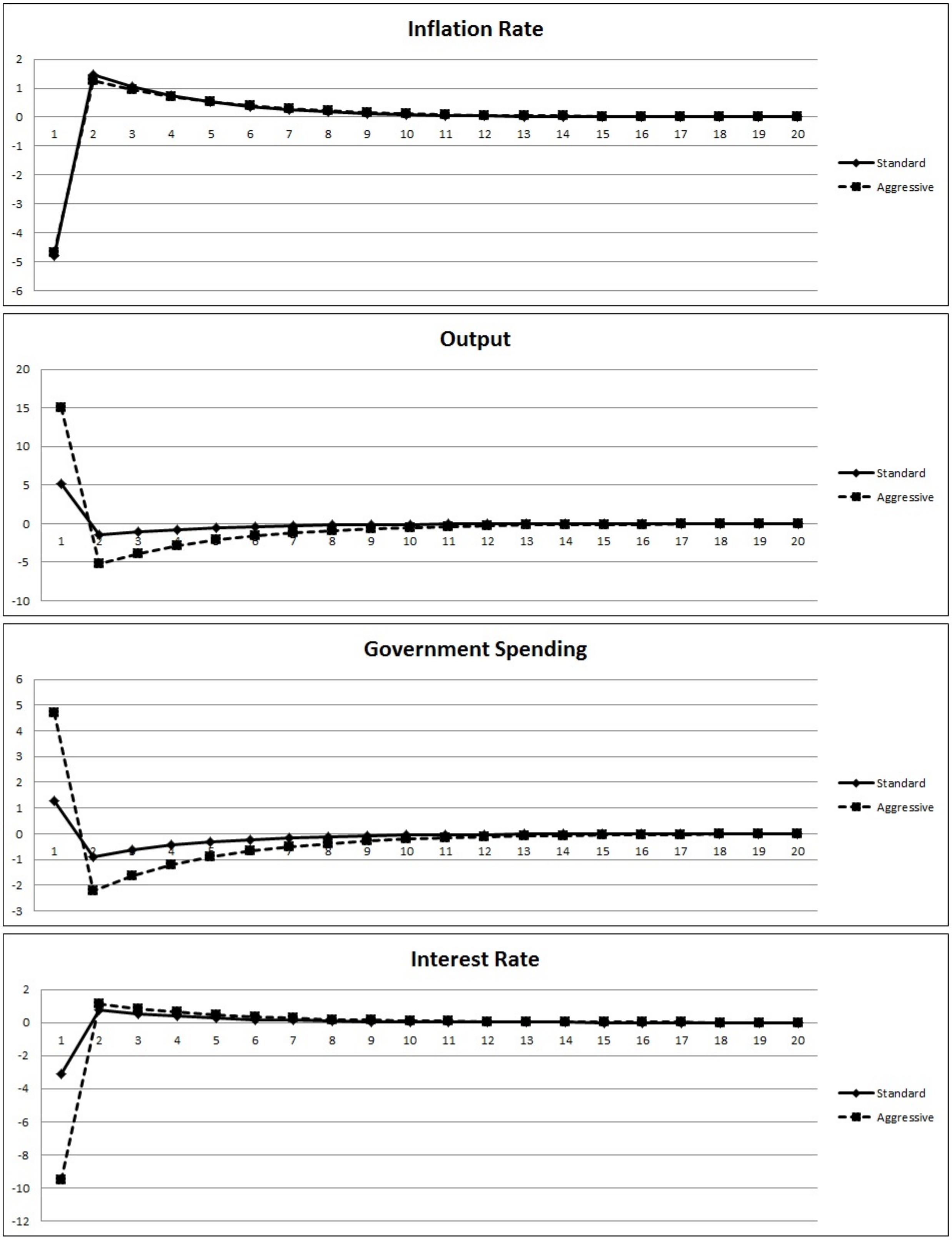

Figure 6: Impulse Response to 1% Positive Productivity Shock: Standard ($\gamma_\pi = 1.5$) vs. Aggressive ($\gamma_\pi = 5$) Inflation Stabilization Taylor Rule with $\xi = 10$

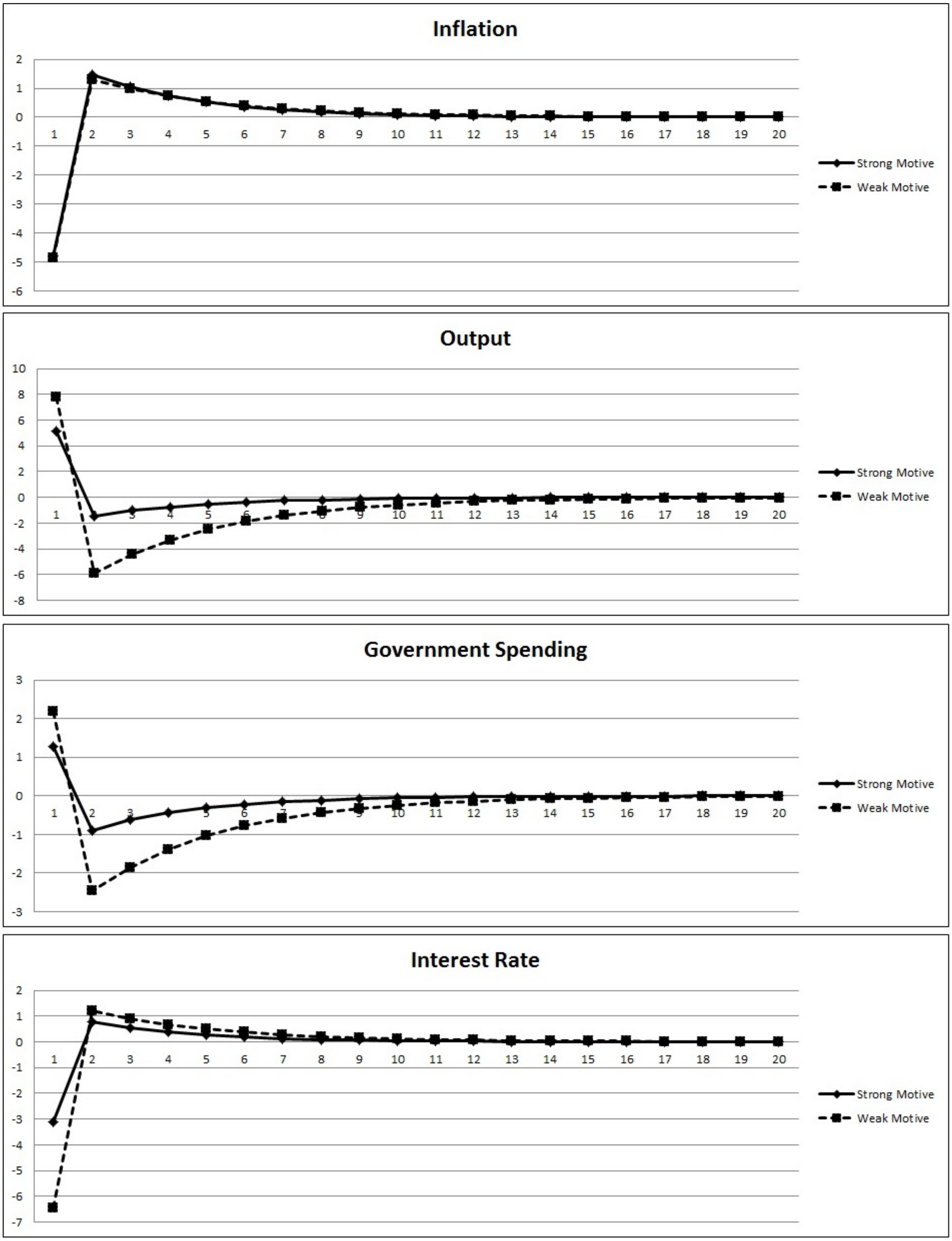

Figure 7: Impulse Response to 1% Positive Productivity Shock: Strong Motive ($\gamma_y = 1$) vs. Weak Motive ($\gamma_y = 0.125$) Output Stabilization Taylor Rule with $\xi = 10$