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Optimal Stabilization Policy in Developing Countries under Frictions: Role of Imperfect Infrastructural Development

Jongheuk Kim
University of Colorado at Boulder

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Department of Economics

University of Colorado at Boulder
Boulder, Colorado 80309

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Department of Economics, University of Colorado at Boulder

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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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e-mail: *jongheuk.kim@colorado.edu*.

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 economy experiences higher level of volatility, and the trade-o between in ation and output gap 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 & Vegh (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 & Vegh (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-Grohe & Uribe (2003), and Schmitt-Grohe & 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

labor supplied, respectively. E_t is de ned by an expectation conditional on all information given at time t. For parameters, $0 < \quad < 1$ is time discounting factor, $\quad > 0$ and $\quad > 0$ stand for inter-temporal elasticity of substitution of private and public consumption, and $' > 0$ is a reverse of an elasticity of labor supply. $_G$ and $_L$ 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 di erentiated goods produced by numerous nal goods producers indexed by $i \; 2 \; [0; 1]$ and de ned by

$$C_t = \int_0^1 C_t(i)^{\frac{\quad 1}{\quad}} di^{\frac{\quad}{\quad 1}} \tag{2}$$

$$G_t = \int_0^1 G_t 1$$

tax or transfer from government, and $_t$ is the the pro t of rms since the rms are assumed to be 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 $0 < \; < 1$ to hold its price at any date. In other words, with the probability $1 \;\;$, a typical firm newly updates its price at each period. $\;$ 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

$$P_t(i) = (1 \quad)P_t\ (i) + \quad P_{t\ 1}(i) \tag{14}$$

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

$$max_{P_t\ (i)} \sum_{s=0}^{1} E_t \quad {}_{t;t+s} \; {}^{s} Y_{t+s}(i)\,(P_t\ (i) \quad MC_{t+s}(i)) \tag{15}$$

such that

$$Y_{t+s}(i) \qquad \frac{P_t\ (i)}{P_{t+s}} \qquad Y_{t+s} \tag{16}$$

$$MC_{t+s}(i) = {}^{W_s}$$

The rst order condition of the maximization problem is reduced to

$$P_t\,(i) = \frac{}{\quad 1}\,\frac{E_t \sum_{s=0}^{1} {}^{s}\ {}_{t;t+s}\ \widehat{MC}_{t+s}(i) P_{t+s}^{\ \ 1} Y_{t+s}}{E_t \sum_{s=0}^{1} {}^{s}\ {}_{t;t+s}\ P_{t+s}^{\ \ 1} Y_{t+s}} \qquad (20)$$

where $\widehat{MC}_{t+s}(i)$ denotes a real marginal cost, $\frac{MC_{t+s}(i)}{P_{t+s}}$. Note that as converges to zero, i.e., the price goes to the fully exible state, the equilibrium price level also settles to the benchmark level, $P_t(i) = \ \widehat{MC}_{t+s}(i)$, where $\ = \frac{}{\ 1}$, the markup revenue. Since the symmetric equilibrium economy and continue to have the frictions permanently. Therefore, there is no sound guarantee that the difference, in short term, $\mathfrak{G}_t$, will be cleared at steady state level. Furthermore, $\mathfrak{G}_t$ is a real adjustment cost departing from the traditional nominal rigidity assumptions such as staggered 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.

$$R_t = R(\ \ _t)\left(\frac{Y_t}{Y_t^n}\right)^{\ \ y} \tag{24}$$

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

3.4 Competitive Equilibrium

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

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

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

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

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:

$$\widehat{mc}_t = (\varphi + \quad \frac{Y}{C})y_t \qquad \frac{G}{C}(1 + \quad \hat{G})g_t \qquad (\varphi + 1)a_t \tag{32}$$

Substituting (32) into (30) with "gap" variable expression, which is defined by the difference between

between in ation and government spending gap since $_{g;0}$, the so called naive parameter, is smaller than the real value of $_{g}$. 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

$$r_t = r + \quad _t + \quad _y \hat{y}_t \tag{36}$$

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

Another important macroeconomic equation is a so called IS relation, which can be obtained by log-linearizing the rst 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

$$\hat{y}_t \quad _g \hat{g}_t = \frac{C}{Y}\frac{1}{\ }(r_t \quad E_t \quad _{t+1}) + E_t \hat{y}_{t+1} \quad _g E_t \hat{g}_{t+1} + \quad _{g;n} E_t \quad g^n_{t+1} + \quad _a (E_t a_{t+1} \quad a_t) \tag{37}$$

where

$$
\begin{aligned}
_g &= \frac{G}{Y}(1 + \quad \hat{\Theta}) \\
_{g;n} &= \quad ' + \left(\frac{Y}{C}\right)^{1} \quad \frac{G}{C}(1 + \quad \hat{\Theta}) \\
_a &= \quad \frac{G}{C}(1 + \quad \hat{\Theta}) \quad \frac{1}{Y}\left(\frac{C}{\ } + G\right) + \frac{\ }{'}^{\,1} \quad 1 + \frac{1}{'} \quad ' + \left(\frac{Y}{C}\right)^{1}(\ ' + 1)
\end{aligned}
$$

and $\quad g^n_{t+1} = g^n_{t+1} \quad g^n_t$. Detailed process of derivation is provided in the technical appendix. (37) indicates that all three parameters $_g$, $_{g;n}$, and $_a$ are a ected by $\hat{\Theta}$ in some extents. As increases, values of three parameters also increase, which induce a steeper slope of IS relation. Especially $_a$ increases with the higher value of , it worsens the trade-o of IS relation. This exacerbated trade-o between variables is clearly captured the amount of $\hat{\Theta}$, and without $\hat{\Theta}$, the IS relation obviously comes back to the benchmark case.

Committee of two economic policy authorities simultaneously choose the optimal set

$f \;\; {}_t; \hat{y}_t; \hat{g}_t; r_t g_{t \;\; 0}$ subject to (33), (36), (37) along with $f y_t^n; g_t^n g_{t \;\; 0}$ that are defined by (34) and (35), and the stochastic process, (29), given $f \;\; {}_1; y \;\; {}_1; g \;\; {}_1; r \;\; {}_1 g$. 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, W

$$W_t = \frac{1}{2} \Bigg[\;\; {}_t^2 + \frac{C^2 + (1 \quad)}{Y} c_t^2 + (1 \quad Y) y_t^2 + \Bigg(\frac{\hat{G} + \;\; G^2}{Y} \Bigg) g_t^2 + $$

parameters in uences 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 means the ampli ed penalty of the government spending spread on the economy, the policy maker perceives that with the increase the economy will lose more welfare gains from government spending part. This results in an ine ectiveness of scal policy with higher level of .

4.3 Optimal Policy Problem

A Ramsey problem using LQ approximation is de ned by a maximization of the sequence of (38) subject to (33) and (37). The choice set is $f \ _t; y_t; g_t g_{t \ 0}$. r_t is automatically determined sequentially by (36).

$$
max_{\ _t;y_t;g_t} E_0 \sum_{t=0}^{\infty} {}^t L_t \tag{40}
$$

where the formulated Lagrangian equation is given by

$$
\begin{aligned}
L_t = \mathrm{W}_t + \ _{1;t} (\ (\ _y y_t \ \ _g g_t) + \ E_t \ _{t+1} \ \ _t) \\
+ \ _{2;t} \ \frac{C}{Y} \frac{1}{\ } (r_t \ \ E_t \ _{t+1}) + E_t y_{t+1} \ \ _g E_t g_{t+1} + \ _{g;n} E_t \ g^n \ \ d \ E_t \ d
\end{aligned}
$$

where $^{d}_{1;t}$ and $^{d}_{2;t}$ are the discretion-speci c shadow prices, and taking $D_{w;t}$, $D_{1;t}$ and $D_{2;t}$

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 rst order conditions:

$$_{t} \quad _{1;t} + \quad ^{1} \quad _{1;t \quad 1} = 0 \tag{47}$$

$$_{y}y_{t} \quad _{y;g}g_{t} + 2(1 \quad ')a_{t} + \quad _{y} \quad _{1;t} \quad _{2;t} + \quad ^{1} \quad _{2;t \quad 1} = 0 \tag{48}$$

$$_{g}g_{t} \quad _{y;g}y_{t} \quad _{g} \quad _{1;t} + \quad _{g} \quad _{2;t} + \quad ^{1} \quad _{g} \quad _{2;t \quad 1} = 0 \tag{49}$$

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

$$_{t} = \frac{1}{(\quad _{y} \quad _{g})} \quad \frac{_{y;g}}{_{g}} + \quad _{y} \quad (y_{t} \quad ^{1}y_{t \quad 1}) \quad \frac{_{y}}{_{g}} + \quad _{y;g} \quad (g_{t} \quad ^{1}g_{t \quad 1}) + 2(1 \quad ')(a_{t} \quad ^{1}a_{t \quad 1}) \tag{50}$$

In the commitment case, unlike the discretion strategy, the e ect of variables on $_t$ is one time lagged with discounting factor . While policy makers in discretion case should not believe that his policy decision a ects on future economic changes since the in ation is purely independent of past or future period, the policy makers in commitment case should take into account the lagged e ect of variables. In addition, note that coe cients on the lagged values of y_t and g_t are slightly di erent from the discretion case. While in discretion case coe cients are weighted by $1 \quad \frac{1}{_{g}} \quad ^{1}$, which includes Θ and is used in IS relation, a commitment case variables are weighted by $\frac{1}{(\quad _{y} \quad _{g})}$, which also includes Θ but it is used in NKPC. Moreover, the e ect of the level of can be observed as in the discretion case. Taking total derivative of $_t$ with respect to shows the similar result with the discretion case, arguing the importance of 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 di erent weights on in ation and output stabilization under LQ welfare loss criteria.

I compare those policy regimes to nd 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 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, and $_y$. 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 is 1.5 to 5, and $_y$ 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 changes from 0 to 10, and Figure 2 shows a change of correlations between output and interest rate as changes from 0 to 10. Observing that both correlations close to absolute value 1 as diverges, Figure 1 and 2 clearly show that higher level of procyclity of fiscal and monetary policy are conducted as , 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 . 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 . In Figure 1, there is a kinked period of the curve in which correlations around = 1 and = 2 are lower than a correlation at = 0. This curious result can be interpreted as a situation where the positive effect of 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, . 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 , 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 . Moreover, as Table 2 represents, higher level of generates more volatility in every part of the economy. The positive cost push shock is ampli ed by higher value of in (33), and thus the policy maker, which has only two policy tools in present period, $\hat{y}_t$ and $\hat{g}_t$, has to sacri ce the higher level

5.5 Discretion versus Commitment

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 nancial markets or signi cant change in international capital ows in the recent decade.

A E cient 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

$$' l_t \quad a_t = \quad c_t = \quad g_t \tag{52}$$

Note that the second equality comes from the e cient 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

$$g_t = \frac{1}{Y}\left(\frac{C}{} + G\right) + \frac{}{'}^{1}\left(1 + \frac{1}{'}\right)a_t \tag{54}$$

which corresponds to (35).

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

$$y_t = (' + \quad \frac{Y}{C})^{\ 1} \quad \frac{G}{C} g_t^n + (' + 1) a_t \tag{55}$$

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 in ation changes:

$$c_t = (r_t \quad _{t+1}) \quad c_{t+1} \tag{56}$$

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, $Y_t = C_t + G_t + \frac{}{2}(G_t \quad G_t^n)^2$ and rewrite it with the expression of c_t,

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

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

$$y_t \quad \frac{G}{Y}(1 + \quad \Theta) g_t =$$

expression for $\hat{y}_t$ and $\hat{g}_t$:

$$\hat{y}_t + (\,' + \frac{Y}{C})^{\;\;1} \quad \frac{G}{Y}(1+\hat{G}) \;\; g_t^n + (\,' + \frac{Y}{C})^{\;\;1}(\,' + 1)a_t \quad \frac{G}{Y}(1+\hat{G})\hat{g}_t$$

$$\frac{G}{Y}(1+\hat{G})(\frac{1}{Y}(\frac{c}{} + G) +$$

and (69), the welfare measure at time t is given by

$$V_t = U_C C \quad c_t + \frac{G}{C} g_t \quad \frac{L}{C} l_t + \frac{1}{2}(1 \quad) c_t^2 + \frac{1}{2}(1 \quad) g_t^2 + \frac{1}{2}(1 + \ ') l_t^2 \quad + t{:}i{:}p{:} + O(k \ "_a \ k^3) \quad (68)$$

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, $Y_t = C_t + G_t + \frac{}{2}(G_t \quad G_t^n)^2$ and the technology of the economy, $Y_t = A_t N_t$.

$$Y y_t + \frac{1}{2} y_t^2 = \frac{1}{2} \ ^2 + (1 + \ \hat{G}) G g_t + \frac{1}{2}(1 + \ \hat{G} + \ G^2) g_t^2 + C c_t + \frac{1}{2} C^2 c_t^2 \quad (69)$$

$$l_t = y_t + \frac{1}{2} y_t^2 \quad y_t a_t \quad \frac{1}{2} l_t^2 \quad (70)$$

Substituting (71) into (70) gives

$$V_t = U_C C \quad \frac{1}{2}\frac{1}{Y}(1 + \ \hat{G} + \ \hat{G}^2) g_t^2 \quad \frac{1}{2}\frac{C^2}{Y} c_t^2 \quad \frac{G}{Y} \ \hat{G} g_t + \frac{1}{2} Y y_t^2 \quad \frac{1}{2} y_t^2 + y_t a_t + \frac{1}{2} l_t^2 + \frac{1}{2Y}(1 \quad) c_t^2 + \frac{1}{2Y}(1$$

$$= U_C C \quad (\frac{C^2}{Y} + \frac{(1 \quad)}{Y}) c_t^2 + (Y \quad 1) y_t^2 + 2 y_t a_t + (\ \frac{(1 + \ G\hat{G})}{Y} + \frac{(1 \quad)}{Y}) g_t^2 \quad ' l_t^2 \quad + t{:}i{:}p{:} + O(k \ "_a \ k^3)$$

which corresponds to (38).

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Table 1: Baseline Parameter Values

Symbol	Name	Estimated Value
′	Reverse of Elasticity of Labour Supply	1
	Inter-temporal Elasticity of Substitution in Private Consumption	2
	Inter-temporal Elasticity of Substitution in Public Consumption	2
	Time Discount Factor	0.985
	Intra-tempotal Elasticity of Substitution between Di erentiated Goods	11
	Markup Revenue	0.1
	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
	Degree of severeness of real friction in the government spending spread	[0, 10]
	Coe cient of AR(1) process	0.9
″a	Standard Deviation of Productivity Shock	0.8125
	Benchmark Policy Parameter for log of In ation	1.5
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 Di erence:

Table 4: Evaluation of Alternative Monetary Policies

	1.5	5	1.5
y	1	1	0.125
STD( )	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

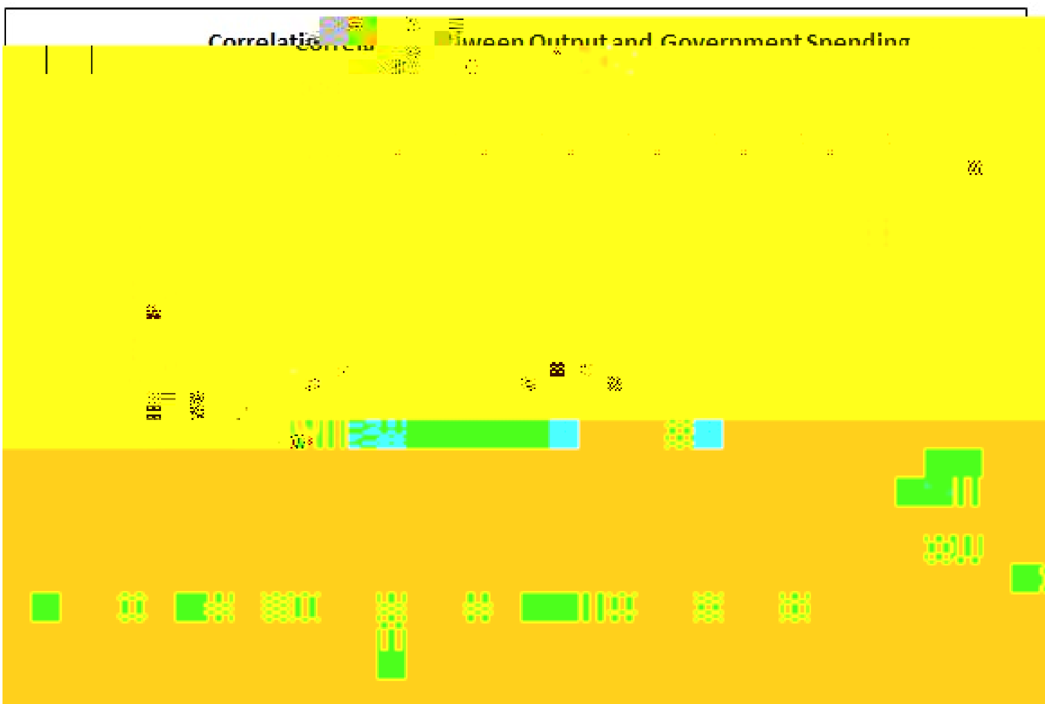

Figure 1: Change of Correlation between Output and Government Spending with respect to Change of

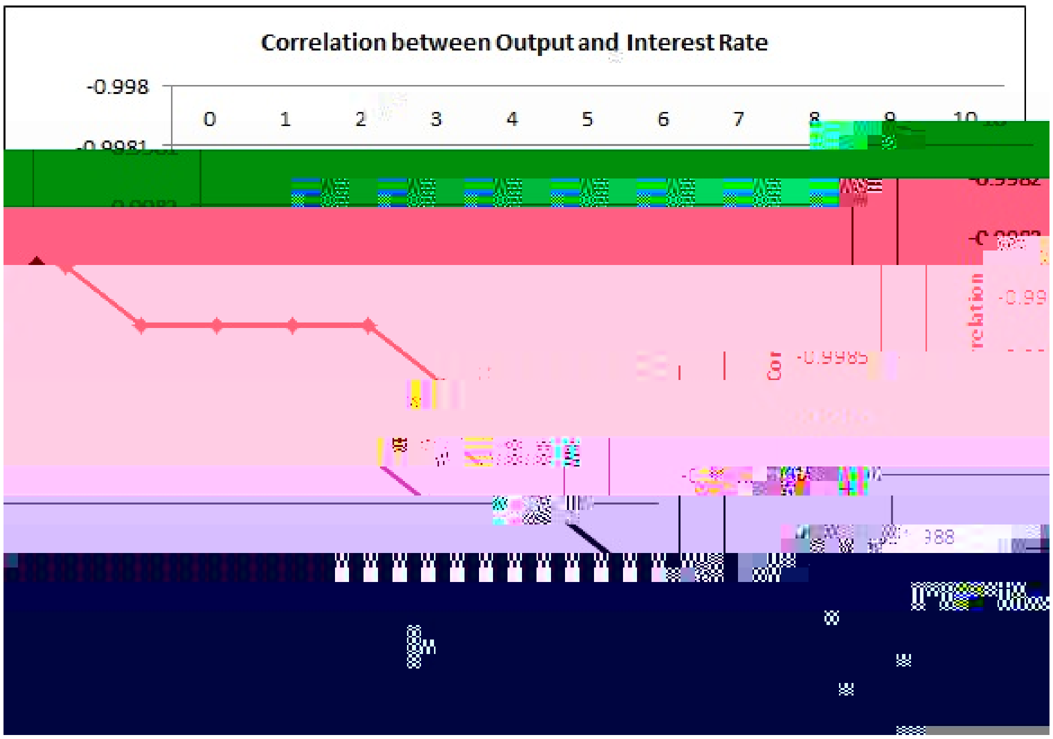

Figure 2: Change of Correlation between Output and Interest Rate with respect to Change of

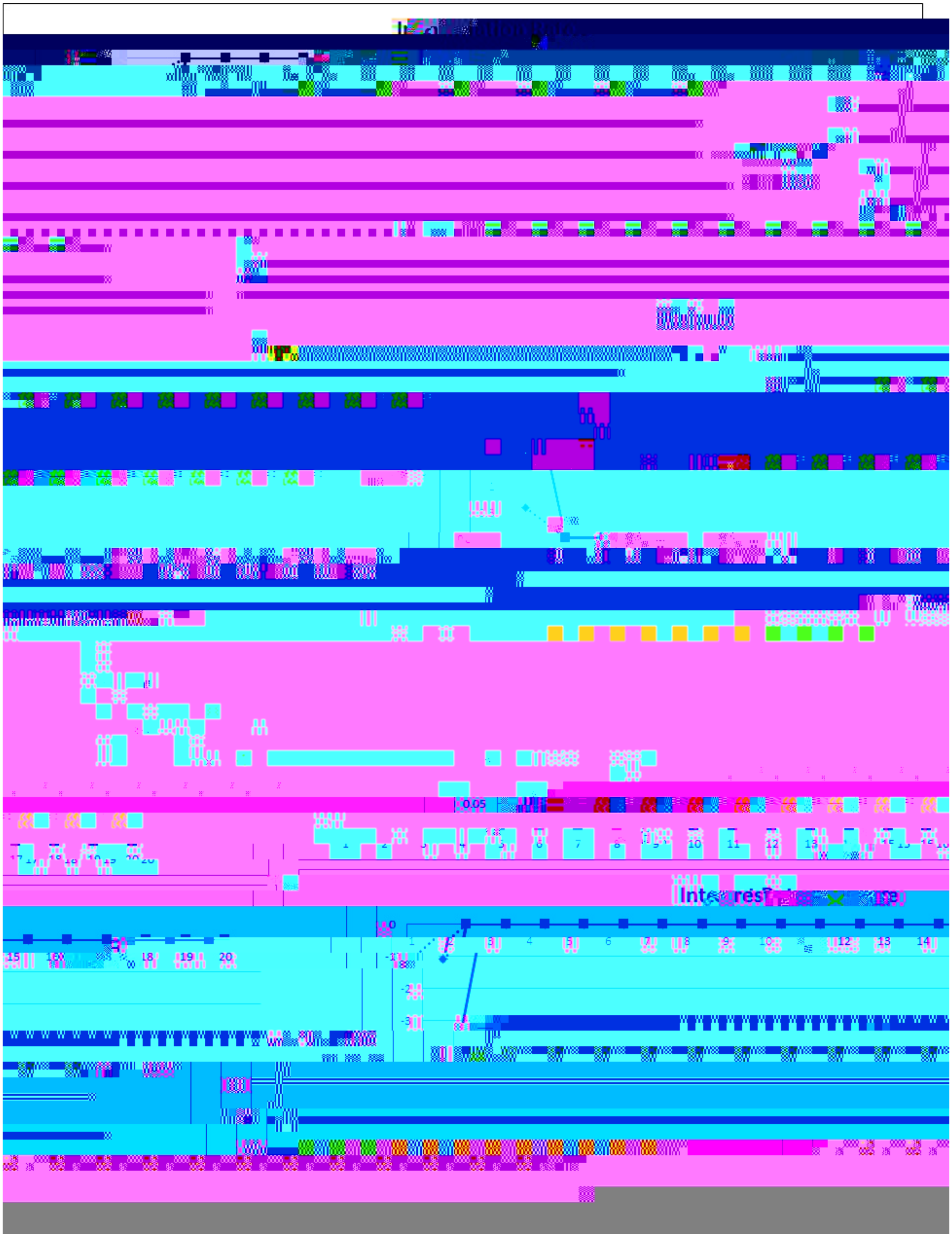

Figure 3: Impulse Responses to 1% Positive Productivity Shock under Discretion: Variation of

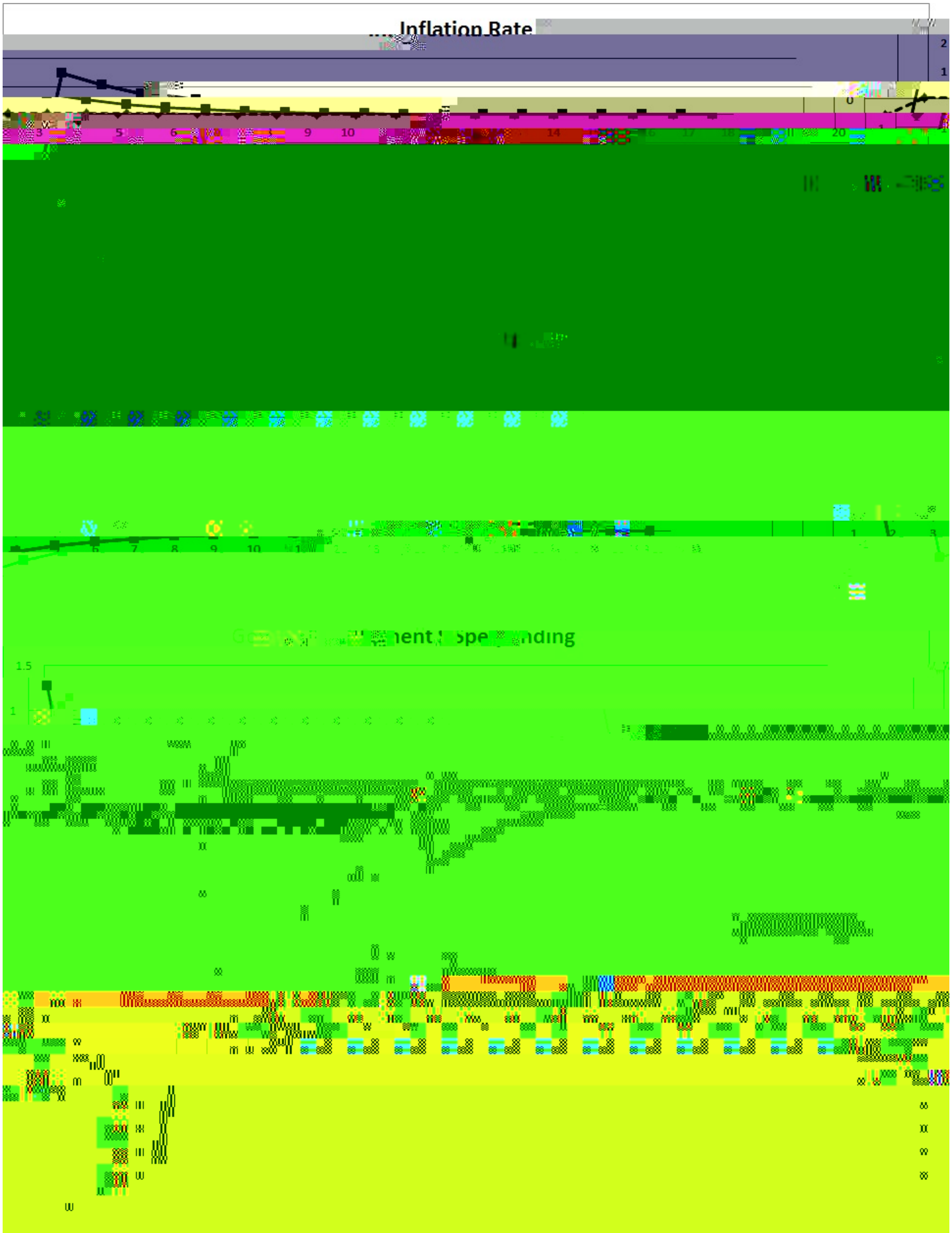

Figure 4: Impulse Response to 1% Positive Productivity Shock under Commitment: Variation of

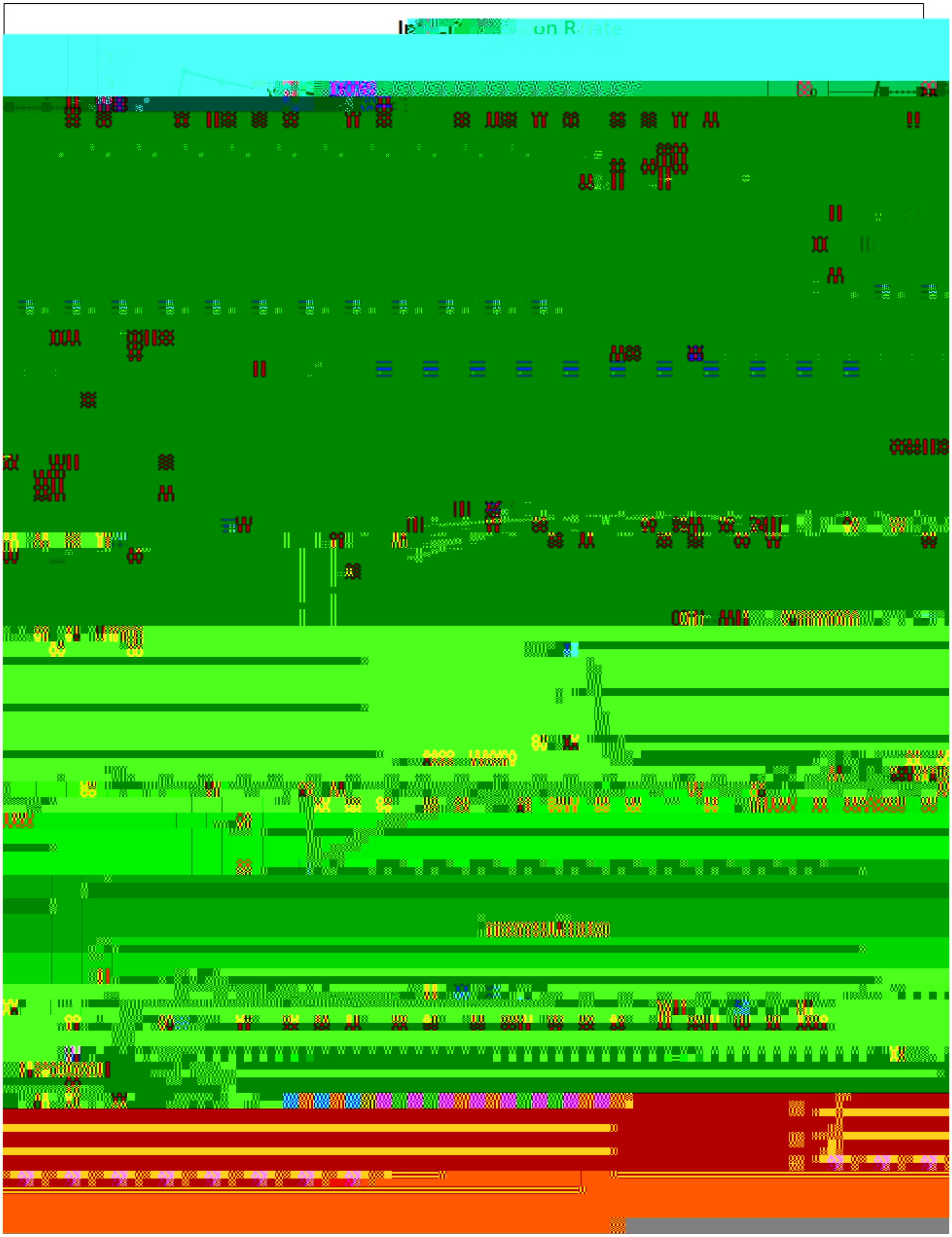

Figure 5: Impulse Response to 1% Positive Productivity Shock: Discretion vs. Commitment with = 10

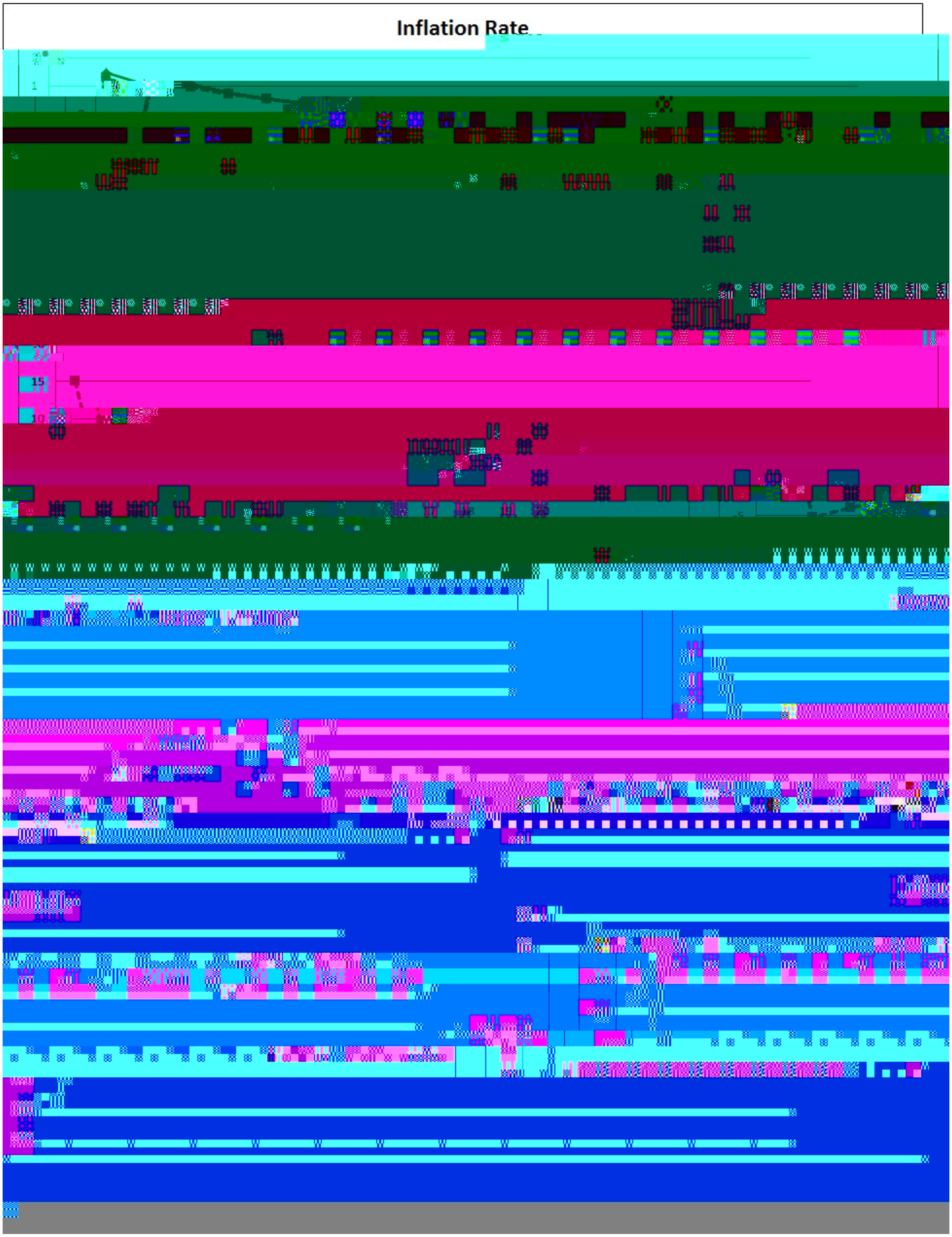

Figure 6: Impulse Response to 1% Positive Productivity Shock: Standard (= 1:5) vs. Aggressive (= 5) In ation Stabilization Taylor Rule with = 10

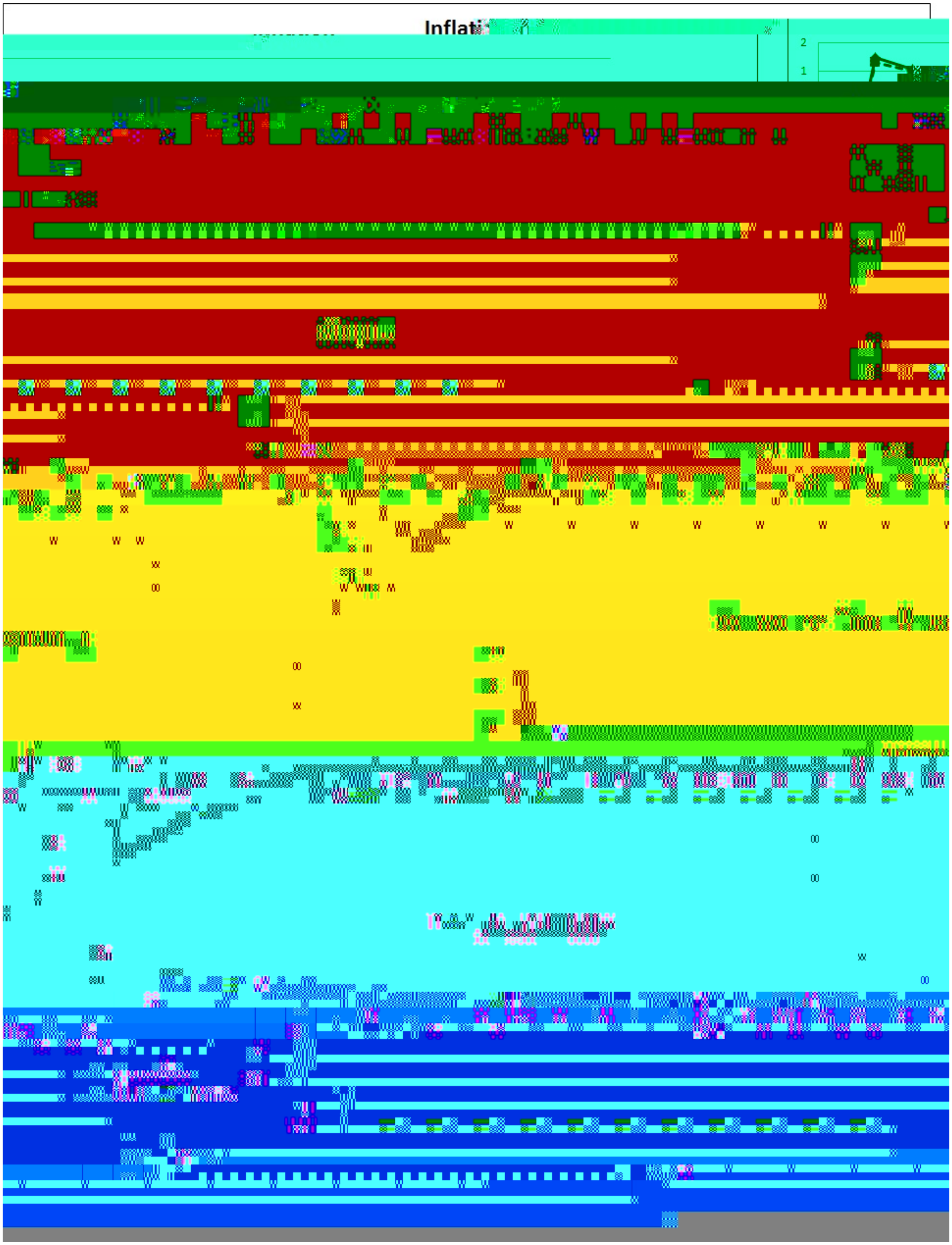

Figure 7: Impulse Response to 1% Positive Productivity Shock: Strong Motive 9enk: