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Deep Habits, Rule-of-Thumb Consumers, and Fiscal Policy*

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Procyclical movements in private consumption and countercyclical markup are the most prominent feature to an increase in government spending. In this paper, we model deep habits and rule-of-thumb consumers to match this feature. We demonstrate that when rule-of-thumb consumers meet deep habits in consumption, our model improves the two models that are widely used in the literature to investigate the effect of government spending. First, it generates a more realistic markup response. Second, it reduces the threshold value of rule-of-thumb share necessary to crowd in consumption. The main reason behind the success is because both deep habits and rule-of-thumb consumers mutually reinforce.

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I. Introduction

Recently, there has been a rising interest in modeling the effect of government spending on the economy. One of the key issue is to explain comovement between government expenditure and private consumption.[1] However, a positive response of private consumption to the shock to government spending is a challenge for the neoclassical model that leads to a fall in consumption via negative wealth effect.

In an attempt to solve the inconsistencies between empirical and theoretical predictions, there have been a variety of models proposed in the literature.

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[1] According to several VAR-based empirical studies, government spending generates persistent increase in consumption. e.g. Fàtas and Mihov (2001), Blanchard and Perotti (2002), and Galí, López-Salido, and Vallés (2007).

Linnemann and Schabert (2003) show that in a model with sticky prices firms raise labor demand putting upward pressure on real wage. As long as monetary policy rule does not put significant weight on output, it is possible to see real wage rise. However, this is not sufficient to counteract the negative wealth effect and thus the sign of consumption remains negative. Galí, López-Salido, and Vallés (2007) present the sticky price model with rule-of-thumb consumers who cannot borrow or lend and therefore consume their entire current disposable income. This type of consumers, who are partly insulated from the wealth effect on labor, makes labor supply curve shift out less in response to a government purchase shock. Therefore, the upward pressure on real wage is greater than the case in which only sticky prices are modeled. As a result, rule-of-thumb consumers raise their spending correspondingly to the increased labor income. If the share of this type of household is sufficient, it is possible to observe the positive response of consumption. However, their model has been questioned in that they rely on large portion of rule-of-thumb consumers.[2]

Another successful approach to predict the effect of government spending is modeling preferences called "Deep Habits" introduced by Ravn, Schmitt-Grohé, and Uribe (2006). While consumers with superficial habits pay attention to habits formed at the level of aggregate consumption, those with deep habits form habits at the level of individual goods.[3] The model with this feature characterizes demand function with price-elastic term that depends on the aggregate demand and perfectly price-inelastic term. When government spending takes place, the share of price-elastic term in the entire demand rises inducing a decline in markup by firms. This effect leaves space for real wage to increase resulting in a rise in consumption. However, their model has been criticized for the counterfactually sizable fall in markup compared to a very small positive response of consumption.[4]

Although the role of deep habits and rule-of-thumb consumers in fiscal transmission have been investigated seperately, the question remains; How does the equilibrium path look like, if those two factors are embedded altogether? Our answer is that coexistence of the two in the model can improve the models that consider them seperately.

This paper adopts the modified deep habit model of Ravn et al. (2006) and incorporate rule-of-thumb consumers. While they assume deep habits in both

[2] In their benchmark solution, the rule-of-thumb share is 0.5, while Cogan, Cwik, Taylor, and Wieland (2010), Forni, Monteforte, and Sessa (2009), and Coenen and Straub (2005) report 0.29, 0.34, and 0.246, respectively.

[3] "superficial habits" is the terminology used by the authors referring to standard habits.

[4] According to the authors, when government spending increases by 1 percentage point of GDP, for 0.05 percent rise in consumption, 5 percent decline in markup is required. However, Monacelli and Perotti (2008) provided empirical evidence that consumption initially rises by 0.1 percent, whereas the markup falls by 0.5 percent.

government expenditure and consumption, we assume deep habits only in consumption. This is because concept of habit formation in government spending is not theoretically investigated in macroeconomic literature. Furthermore, there is micro evidence only on deep habits in consumption. For instance, Verhelst and Van den Poel (2012) estimate a spatial panel model using scanner data from a large European retailer and show external deep habit is significant.

Our main finding is that when deep habits only in consumption meet rule-of-thumb consumers, the model generates positive consumption response without generating large markup drop relative to the model of deep habits in both government purchase and consumption (i.e. Ravn et al., 2006). Furthermore, the model relies less on rule-of-thumb consumers than the model with those type of consumers without habits (i.e. Galí et al., 2007) to crowd in consumption.

The economic intuition underlying this mechanism is explained as follows. Note that negative wealth effect driven by government spending shock depresses the consumption of Ricardian households. As a consequence, their spending falls, hours worked increase and, thereby, real wage falls. In order to observe a rise in consumption, the real wage must increase sufficiently, which can be achieved by either making labor supply curve shift less or expanding labor demand more. In the model of Ravn et al. (2006), significant expansion of labor demand by excessive markup drop dominates an increase in labor supply. However, under deep habits only in consumption, such movement in markup becomes weaker because of small price-elastic term. Rule-of-thumb consumers make labor supply curve shift out less. In addition to such traditional role, more importantly, it attenuates the countercyclicality of markup generated by deep habits as price-elastic term shrinks more. Although the effect of deep habits on markup is dampened due to presence of rule-of-thumb consumers, since it is still alive as long as Ricardian consumers sufficiently exist, expansion of labor demand is stronger relative to the model of Galí et al. (2007). This admits labor supply to have freedom to shift more, requiring smaller fraction of rule-of-thumb consumers. All in all, rule-of-thumb consumers prevent sizable markup drop induced by deep habits and deep habits lower rule-of-thumb share.

Alternative model that accounts for procyclical consumption and countercyclical markup is as follows. Monacelli and Perotti (2008) incorporate preferences introduced by Greenwood, Hercowitz and Huffman (1988) in sticky price model. With price stickiness, these preferences, which enable weak wealth effect on labor supply, boost up real wage sufficiently to overcome the negative wealth effect. However, GHH preferences are incompatible with balanced growth path, making it difficult to assess against other models based on Bayesian comparison.

The rest of the paper is organized as follows. Section 2 outlines sticky price model incorporated with deep habits and rule-of-thumb consumers. Section 3 presents the theoretical investigation of the model. Section 4 describes the parameter calibration. Section 5 contains simulations of the model. Section 6 concludes.

II. The Model

2.1 Households

There is a continuum of infinitely lived households indexed by $i \in [0,1]$. $1-\lambda$ of households have complete access to capital markets, where they trade securities or accumulate and rent out physical capital to firms. At any point, they make consumption decision based on lifetime income. We term them optimizing households or Ricardian households. A fraction λ of households cannot borrow or save, thereby, their current after-tax labor income is the only source of spending. We label these borrowing constrained households rule-of-thumb households or non-Ricardian households. Henceforth, the variables that correspond to the optimizing households and rule-of-thumb households are superscripted as 'o' and 'r', respectively.

Also, it is assumed that household supplies a differentiated labor service to a labor packer to be aggregated in the way:

$$N_t = \left(\int_0^1 (N_t^i)^{\frac{\eta_w - 1}{\eta_w}} \mathrm{d}i \right)^{\frac{\eta_w}{\eta_w - 1}}, \tag{1}$$

where η_w is the elasticity of substitution across different types of labor indexed by i. Given the labor specific real wage rate W_t^i, each labor type required is

$$N_t^i = \left(\frac{W_t^i}{W_t} \right)^{-\eta_w} N_t^d, \tag{2}$$

where N_t^d is aggregate labor demand and W_t is an index of the wages prevailing in the economy at time t.

2.1.1 Ricardian Households

Each household derives utility from consumption measure X_t^c and disutility from hours worked N_t^o. The expected lifetime utility of household is of the form:

$$E_t \sum_{t=0}^{\infty} \beta^t U(X_t^c, N_t^o).$$

We asume that utility is seperable in consumption and leisure, namely

$$U(X_t^c, N_t^o) = \frac{X_t^{c1-\sigma} - 1}{1-\sigma} + \gamma \frac{(1-N_t^o)^{1-\chi} - 1}{1-\chi}, \tag{3}$$

where $0 < \sigma \neq 1, 0 < \chi \neq 1$, and $\gamma > 0$. $X_t^c = (\int_0^1 (C_{jt}^o - b^c S_{jt-1}^c)^{\frac{\eta_p - 1}{\eta_p}} \mathrm{d}j)^{\frac{\eta_p}{\eta_p - 1}}$ denotes a composite of habit-adjusted consumption of differentiated goods indexed by j with S_{jt-1}^c representing the stock of habit. $b^c \in [0,1)$ measures the degree of habit formation and assigning 0 gives standard time-seperable utility. The stock of habit is assumed to depend on a weighted average of consumption in all past period. Formally, S_{jt}^c can be written as:

$$S_{jt}^c = (1-\rho^c) \sum_{k=0}^{\infty} \rho^{ck} C_{jt-k}^o = (1-\rho^c) C_{jt}^o + \rho^c S_{jt-1}^c, \tag{4}$$

where parameter $\rho^c \in [0,1)$ measures the speed of adjustment of the stock of habit to variations in the cross-sectional average level of consumption of variety j. $\eta_p > 0$ denotes the elasticity of substitution across habit-adjusted consumption of different varieties. σ represents the relative risk aversion coefficient and χ is preference parameter. Finally, the utility is discounted at $\beta \in (0,1)$.

For any given level of composite habit-adjusted consumption X_t^c, purchases of each variety of goods j in period t must solve the dual problem of minimizing total expenditure, $\int_0^1 P_{jt} C_{jt}^o \mathrm{d}j$, where P_{jt} denotes the nominal price of a good j at time t. Then the demand of Ricardian household for consumption good j is given by:

$$C_{jt}^o = \left(\frac{P_{jt}}{P_t} \right)^{-\eta_p} X_t^c + b^c S_{jt-1}^c, \tag{5}$$

where $P_t \equiv (\int_0^1 P_{jt}^{1-\eta_p} \mathrm{d}j)^{\frac{1}{1-\eta_p}}$ is a nominal price index. At the optimum, $P_t X_t^c = \int_0^1 P_{jt} (C_{jt}^o - b^c S_{jt-1}^c) \mathrm{d}j$ holds.

Similarly, investment is assumed to be a composite of differentiated investment goods:

$$I_t^o = \left(\int_0^1 (I_{jt}^o)^{\frac{\eta_p - 1}{\eta_p}} \mathrm{d}j \right)^{\frac{\eta_p}{\eta_p - 1}}. \tag{6}$$

By constructing the cost minimizing problem as in consumption, the demand for each investment good is given by:

$$I_{jt}^{o} = \left(\frac{P_{jt}}{P_t}\right)^{-\eta_p} I_t^{o}. \tag{7}$$

The household enters period t with a stock of one-period government bonds carried over from period $t-1, B_t^o$. L_{t+1} is the payoff in period $t+1$ of state contingent securities traded in period t at a price $m_{t,t+1}$. During the period, the household receives real wage, W_t, real rental price of capital, R_t^k, and dividends, D_t, paid by firms. It is required to pay lump-sum tax, T_t^o. These resources are used to purchase nondurable consumption goods and to acquire new bonds at price $\frac{1}{R_t}$. Then the household's period-by-period budget constraint can be expressed as[5]

$$\begin{aligned} &E_t m_{t,t+1} L_{t+1} + X_t^c + \omega_t + I_t^o + \phi\left(\frac{K_{t+1}^o}{K_t^o}\right) K_t^o + T_t^o + \frac{B_{t+1}^o}{R_t} \\ &= W_t N_t^o + R_t^k K_t^o + D_t^o + \frac{B_t^o}{\Pi_t}, \end{aligned} \tag{8}$$

where $\omega_t = b^c \int_0^1 \frac{P_{jt}}{P_t} S_{jt-1}^c \mathrm{d}j$ and $\Pi_t = \frac{P_t}{P_{t-1}}$. $\phi(\frac{K_{t+1}^o}{K_t^o}) = \frac{\kappa}{2}(\frac{K_{t+1}^o}{K_t^o} - 1)^2$ captures the costly adjustment of the capital stock. The evolution of capital stock is given by:

$$K_{t+1}^o = (1-\delta) K_t^o + I_t^o, \tag{9}$$

where δ is the depreciation rate.

2.1.2 Rule-of-Thumb Households

We introduce non-Ricardian households who are assumed to behave in a "hand-to-mouth" fashion, fully consuming their current labor income. Therefore, their consumption rule is given as follows:

$$C_t^r = W_t N_t^r - T_t^r, \tag{10}$$

where T_t^r is the tax burden. We assume that the tax paid by rule-of-thumb consumers is constant, so that $T_t^r = \tau^r$. Also, taxes of optimizing households are set to keep the government budget balanced.

[5] We omit the superscript i for simplicity.

2.1.3 Aggregation

We denote aggregate consumption, labor, lump sum taxes, capital, investment, dividends and bonds by $C_t, T_t, K_t, I_t, D_t,$ and $B_t,$ respectively. These are defined as

$$C_t = \lambda C_t^r + (1-\lambda)C_t^o; \quad N_t = \lambda N_t^r + (1-\lambda)N_t^o; \quad D_t = (1-\lambda)D_t^o;$$
$$I_t = (1-\lambda)I_t^o; \quad K_t = (1-\lambda)K_t^o; \quad T_t = \lambda T_t^r + (1-\lambda)T_t^o. \tag{11}$$

2.2 Fiscal and Monetary Policy

Government is also assumed to form habits over each variety of goods j. For any given level of composite government purchase, $X_t^g = (\int_0^1 (G_{jt} - b^g S_{jt-1}^g)^{\frac{\eta_p - 1}{\eta_p}} dj)^{\frac{\eta_p}{\eta_p - 1}}$, solving the cost-minimization problem as in the previous subsection results in demand for good j by the government expressed as:

$$G_{jt} = \left(\frac{P_{jt}}{P_t}\right)^{-\eta_p} X_t^g + b^g S_{jt-1}^g. \tag{12}$$

The stock of habit is assumed to evolve as:

$$S_{jt}^g = \rho^{gg} S_{jt-1}^g + (1-\rho^{gg}) G_{jt}.$$

The government spending is assumed to evolve exogenously according to the following process:

$$\log\left(\frac{G_t - G}{Y}\right) = \rho^g \log\left(\frac{G_{t-1} - G}{Y}\right) + \varepsilon_t, \tag{13}$$

where $0 < \rho^g < 1$, and ε_t represents *i.i.d* government spending shock with mean zero and variance σ^2. Variable without subscript t denotes steady state level of the corresponding variable. Because Ricardian equivalence holds in our model, it is redundant to introduce debt in government budget constraint. Hence, we assume government expenditure is financed by lump sum taxation.

We assume that the central bank sets its gross nominal interest rate, according to the following Taylor-type rule:

$$\log\left(\frac{R_t}{R}\right) = \alpha_R \log\left(\frac{R_{t-1}}{R}\right) + (1-\alpha_R)\alpha_\pi \log\left(\frac{\Pi_t}{\Pi}\right), \tag{14}$$

where Π_t, R_t and Y_t are gross inflation rate, nominal interest rate, and output, respectively. If $\alpha_R > 0$, the rule allows for interest rate inertia.

2.3 Firms

Each variety of goods is produced by a monopolistically competitive firm, indexed by $j \in [0,1]$. The production function for each firm is given by

$$Y_{jt} = K_{jt}^{\alpha} N_{jt}^{1-\alpha} - \vartheta, \tag{15}$$

where Y_{jt} denotes output of good j, K_{jt} and N_{jt} denote capital and labor utilized by firm, and ϑ denotes fixed costs of production.[6] The firm is assumed to satisfy demand at the posted price. Formally,

$$Y_{jt} \geq C_{jt} + I_{jt} + G_{jt}. \tag{16}$$

Each firm maximizes the present discounted value of dividend payment, given by:

$$E_t \sum_{k=0}^{\infty} m_{t,t+k} P_{jt+k} D_{jt+k}, \tag{17}$$

where $m_{t,t+k}$ is the stochastic discount factor and period t dividend payments are

$$D_{jt} = \frac{P_{jt}}{P_t}(\lambda C_{jt}^r + (1-\lambda)C_{jt}^o + I_{jt} + G_{jt}) - W_t N_{jt} - R_t^k K_{jt} - \omega\left(\frac{P_{jt}}{P_{jt-1}}\right).$$

Following Rotemberg (1982), $\omega(\cdot)$ measures the cost of price changes given as:

$$\omega\left(\frac{P_{jt}}{P_{jt-1}}\right) = \frac{\theta_p}{2}\left(\frac{P_{jt}}{P_{jt-1}} - 1\right)^2,$$

where $\theta_p > 0$.

[6] As fixed costs ensure increasing return to scale technology, we have small profit-to-output ratio in steady state which is consistent with U.S data.

2.4 Market Clearing

The clearing of good, labor, and capital market requires

$$Y_{jt} = C_{jt} + I_{jt} + G_{jt} + \omega\left(\frac{P_{jt}}{P_{jt-1}}\right) + \phi\left(\frac{K_{t+1}}{K_t}\right)K_t \quad \forall j;$$
$$N_t = \int_0^1 N_{jt}\mathrm{d}j; \quad K_t = \int_0^1 K_{jt}\mathrm{d}j. \tag{18}$$

III. Compelementarity between Deep Habits and Rule-of-Thumb Consumers

In this section, we investigate how deep habits and rule-of-thumb consumers mutually reinforce in the sense that deep habits lower the rule-of-thumb-share and rule-of-thumb share has a nature of mitigating a decline in markup generated by deep habits. We first show countercylicality of markup becomes weaker when deep habits are assumed only in consumption relative to deep habits in both consumption and government spending. This is attributable to the size of price-inelastic term.

Specifically, combining equation (5), (6), and (12) with the demand of rule-of-thumb consumers, the demand faced by an individual firm j in period t is of the form:

$$C_{jt} + I_{jt} + G_{jt} = \left(\frac{P_{jt}}{P_t}\right)^{-\eta_p}((1-\lambda)X_t^c + \lambda C_t^r + I_t + X_t^g) + b^c(1-\lambda)S_{jt-1}^c + b^g S_{jt-1}^g. \tag{19}$$

This demand function is composed of two terms. One term is $(\frac{P_{jt}}{P_t})^{-\eta_p}((1-\lambda)X_t^c + \lambda C_t^r + I_t + X_t^g)$, displaying a price elasticity of η_p. The second term is $b^c(1-\lambda)S_{jt-1}^c + b^g S_{jt-1}^g$, which originates exclusively from habitual consumption of good j. Therefore, the second term is perfectly price inelastic. The price elasticity of the demand for good j is a weighted average of the elasticities of the two terms just described, namely η_p and 0. The weight on η_p is given by the share of the price-elastic term in total demand. When the weight of this term increases via a rise in X_t^g induced by government spending at period t, price elasticity increases. Because the markup is inversely related to the price elasticity of demand, it follows that under deep habits, an expansion in government spending induces a decline in markup, shifting out labor demand curve.

Under no habits, the price-inelastic term dissapears implying time invariant markup. More generally, as the price-inelastic term becomes smaller, the countercyclicality of markup becomes weaker. Consider the specification in which deep habits are assumed only in consumption. Demand function, then, is reduced to

$$C_{jt} + I_{jt} + G_{jt} = \left(\frac{P_{jt}}{P_t}\right)^{-\eta_p} ((1-\lambda)X_t^c + \lambda C_t^r + I_t + G_t) + b^c(1-\lambda)S_{jt-1}^c. \tag{20}$$

In this equation, the price-inelastic term is collapsed to $b^c(1-\lambda)S_{jt-1}^c$, so the markup is expected to be muted relative to those under the specification in which deep habits are assumed in both government spending and consumption.

We, then, proceed to discuss complementary relationship between deep habits and rule-of-thumb consumers. Note that the key mechanism to explain positive consumption response relies on dominance of expansion in labor demand over an increase in labor suppy. Under reasonable specification of deep habits (i.e. deep habits only in consumption), since labor demand does not expand strong enough, we need to dampen an increase in labor supply. This is where rule-of-thumb consumers play a role since they are partly muted from the wealth effect on labor. However, in the presence of deep habits, rule-of-thumb share, λ, has additional role. In fact, it works against the fall in markup generated by deep habits. As λ becomes larger, labor supply curve becomes inactive. Moreover, as price-inelastic term of equation (20) gradually vanishes, effect of deep habits on expansion of labor demand gradually dissapears. In the end, without the effect of deep habits, expansion of labor demand is only induced by price stickiness, which is the case in Galí, López-Salido, and Vallés (2007). As long as λ is positive but less than one, one can enjoy an extra labor demand expansion driven by deep habits in addition to that led by price rigidity. Thus, the presence of rule-of-thumb consumers not only annihilates an increase in labor supply but mitigates the extra countercyclicality of markup generated by deep habits. From the viewpoint of rule-of-thumb consumers, existence of deep habits enables smaller rule-of-thumb share, as labor demand shift is larger than that solely driven by price stickiness, allowing some space for an increase in labor supply.

IV. Calibration

Models are calibrated to a quarterly frequency and many of the values are taken from Galí, López-Salido, and Vallés (2007). The discount factor β and the rate of depreciation δ is set equal to 0.99 and 0.025, respectively. The elasticity of output with respect to capital, α, is assumed to be 1/3, which is roughly consistent with the observed capital income share. The elasticity of substitution across goods, η_p, and labor supply, η_w, are both set to 6. Finally, the government purchase-to-output ratio, γ_g is set to 0.2, which roughly corresponds to the average share of government purchase in GDP in post-war U.S. data.

In order to parameterize the degree of price stickiness, by log-linearizing equation (30) around a zero-inflation steady state, we can obtain an elasticity of inflation to real marginal cost that takes the form $\frac{\eta_p - 1}{\theta_p}$.[7] As Woodford (2003) describes, when approximating linearly around zero-inflation steady state one can ignore the state variable related to relative price distortion unless one is interested in the dynamics associated with it. This allows a direct comparison with the New Keynesian Phillips curve using Calvo-Yun approach. With this approach, the slope coefficient of the log-linear Phillips curve is expressed as $\frac{(1-\theta)(1-\beta\theta)}{\theta}$, where θ is the probability of not resetting the price. Thus, matching those two coefficients yields $\theta_p = \frac{Y\theta(\eta_p - 1)}{(1-\theta)(1-\beta\theta)}$, where Y is the steady state output. The resulting stickiness parameter that roughly corresponds to $\theta = \frac{2}{3}$ is $\theta_p = 15$.[8] The baseline value for rule-of-thumb share, λ, is set to 0.3, which roughly corresponds to the estimated values in the literature.[9] The capital adjustment cost parameter κ is set equal to 10, suggested by Ireland (2001). We take calibration of parameters related to preferences from Ravn, Schmitt-Grohé, and Uribe (2006). Deep habit parameters, b^c and b^g, are taken to be 0.86. Persistence of habit stock ρ^c and ρ^{gg} is set equal to 0.85. Steady state hours worked, risk aversion, σ, preference parameter, χ, are assumed to be 0.2, 2, and 3.08, respectively.

The baseline policy parameters are chosen as follows. Interest rate smoothing parameter (α_R) and coefficients on inflation (α_Π) are set to be 0.73 and 0.27, respectively, consistent with the estimates in Iacoviello (2005). For fiscal policy parameters, following Galí et al. (2007), ρ^g is chosen to be 0.9. Table 1 summarizes the values assumed for our baseline parameters.

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[7] In fact, no habits version of equation (30) is log-linearized to be consistent with Phillips curve derived using Calvo-Yun approach.

[8] Estimates on price stickiness vary. Bils and Klenow (2004) argue that the observed frequency of price adjustment in the U.S. is two quarters. Nakamura and Steinsson (2008) estimate an average frequency of adjustment of about four quarters. We take the average, namely 3 quarters, as the baseline. This is parameterized to 2/3 in Calvo lottery.

[9] See Cogan, Cwik, Taylor, and Wieland (2010), Forni, Monteforte, and Sessa (2009), and Coenen and Straub (2005).

[Table 1] Baseline Parameters

Parameters	Values	Description of Paramters
β	0.99	Discount factor
σ	2	Risk aversion
δ	0.025	Depreciation rate
κ	10	Adjustment cost parameter
α	1/3	Elasticity of output with respect to capital
N	0.2	Hours worked
η_p	6	Elasticity of substitution across individual goods
η_w	6	Elasticity of substitution across labor
γ_g	0.2	Share of government purchase in output
α_R	0.73	Interest rate smoothing parameter
α_π	1.27	Inflation coefficient in monetary policy rule
ρ^g	0.9	Persistence of government spending shock
λ	0.3	Rule-of-thumb share
θ_p	15	Price stickiness
b^c, b^g	0.86	Degree of deep habits
ρ^c, ρ^{gg}	0.85	Persistence of habit stock

V. Quantitative Analysis of the Model

In this section, we show that behavior of key variables depends critically on the specification of deep habits. That is, whether assuming deep habits in government spending or not results in completely different pattern in consumption and markup responses. Since neither of these specifications match the model with the empirical results, we assess whether the presence of rule-of-thumb consumers can improve the model's performance. To that goal, we first proceed working with a version of the model without rule-of-thumb consumers and then include them. We compute the equilibrium path of a linear rational expectation model approximated around non-stochastic steady state. The response of consumption is expressed as share of steady state output by multiplying the log response by the steady state share of consumption in output.[10] The responses of hours, the real wage and the markup are expressed in percentage terms. Here, the shock to government spending is normalized to 1 percentage point of steady state output.

[10] The reason why consumption is expressed as share of steady state output is to compare with empirical counterpart that is exhibited in Monacelli and Perotti (2008).

5.1 Deep Habit Economy without Rule-of-Thumb Consumers

We begin with economy where Ricardian consumers form deep habits, assuming away the existence of rule-of-thumb consumers. Figure (1) displays the impulse responses to one percent government purchase shock. The model with deep habits in both government spending and consumption (row 1) exhibits a very little rise in consumption accompanied by about 3 percent fall in markup. However, the value of markup is considered to be unreasonble in the context of empirical evidence.[11] When deep habits are ruled out (row 3), markup falls by about 0.5 percent, which seems to be improved, but consumption fails to rise. It appears that neither specifications can achieve both a rise in consumption and realistic decline in markup. When we simply assume deep habits only in consumption (row 2), depress in consumption is muted compared to the case of no habits. Markup falls by about 0.7 percent which is greater than the value reported in the model with no habits, yet much more reasonable relative to the value predicted in the model with deep habits in both government spending and consumption.

Consider the intuition behind the model with no habits first. An increase in government spending, driven by negative wealth effect, leads to a fall in consumption and an increase in hours. Simultaneously, price stickiness makes it possible for real wage increase as the markup declines sufficiently even in the face of a drop in marginal product of labor. However, the resulting increase in real wage is not sufficient to absorb the negative wealth effect, and therefore consumption remains to be negative. Second, we turn to the economy with deep habits only in consumption. In household side, a drop in consumption by optimizing consumers is subdued due to habit forming behavior. In production side, the monopolist producing good j faces the demand function (20). As we discussed in section 3, in response to a government purchase, the weight of the price-elastic term in total demand increases, and, as a result, price elasticity increases. Subsequently, markup declines by a larger amount. Even if the fall in markup is more sizable relative to markup movements due to price stickiness only, resulting rise in real wage still cannot fully offset the negative wealth effect.

However, in the economy with deep habits in both government expenditure and consumption, government spending generates positive response of consumption. This is because negative response of markup, much larger than in the model with deep habits only in consumption, boosts up real wage to overcome the negative wealth effect.

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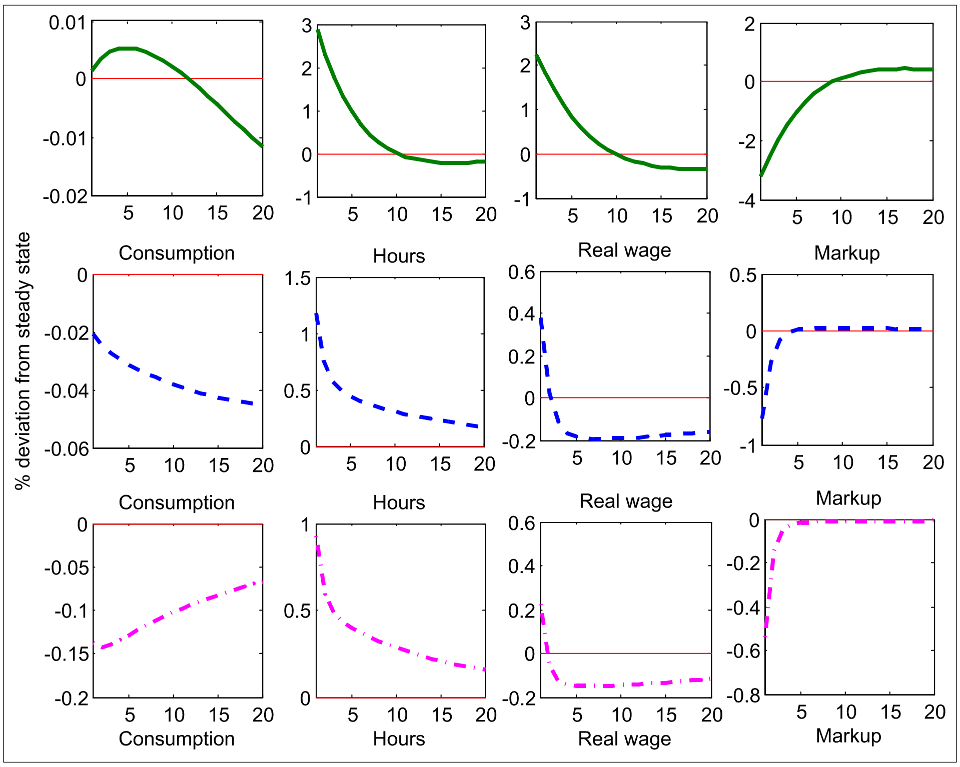
[11] To be in line with the findings presented by Monacelli and Perotti (2008), markup should fall by 0.5 percent initially.

[Figure 1] Impulse responses to a government spending shock in the model without rule-of-thumb consumers

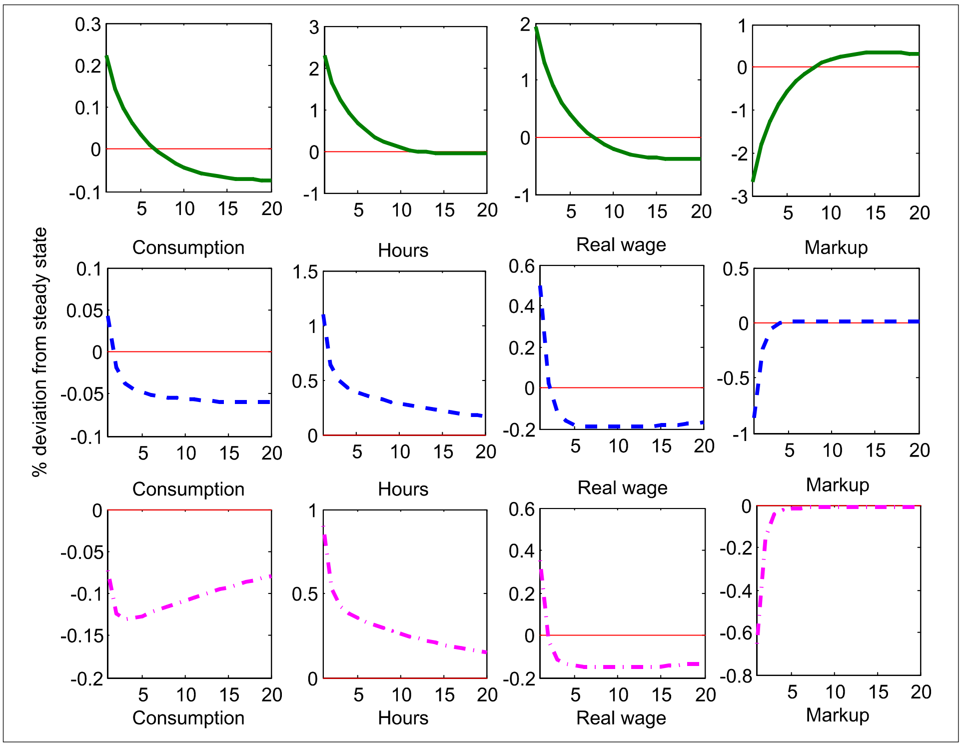


Note: row 1: $b^c = 0.86$, $b^g = 0.86$; row 2: $b^c = 0.86$, $b^g = 0$; row 3: $b^c = 0$, $b^g = 0$.

5.2 Deep Habit Economy with Rule-of-Thumb Consumers

We continue our discussion by introducing rule-of-thumb consumers into our model. Figure (2) plots the impulse responses of key variables to a government spending shock. In contrast to Galí et al. (2007), a rise in consumption is still not realized in the model with no habits (row 3), but it is observed in the model with deep habit preferences only in consumption (row 2). Furthermore, unlike the model with deep habits in both government spending and consumption (row 1), the model with deep habits only in consumption succeeds in generating positive consumption without relying on unrealistic fall in markup. The size of consumption and markup response is 0.05 and 0.9, respectively. These responses, relative to the other two rows, are closer to 0.1 percent increase and 0.5 percent decrease, repectively, evidenced in manufacturing sector based SVAR result of Monacelli and Perotti (2008). Although the response of consumption (markup) is monotonically decreasing (increasing) which contrasts to the gradual increasing (decreasing) pattern observed in their paper, like other models that include rule-of-thumb consumers, we focus on

[Figure 2] Impulse responses to a government spending shock in the model with rule-of-thumb consumers



Note: row 1: $b^c = 0.86$, $b^g = 0.86$; row 2: $b^c = 0.86$, $b^g = 0$; row 3: $b^c = 0$, $b^g = 0$.

predicting the direction of variables and the size of their initial response instead of matching the path.

The intuition behind is simple. Rule-of-thumb consumers are partly immune from the wealth effect on labor supply. Even though their hours worked increase, unlike optimizing consumers, they lack the incentive to smooth out their consumption path. This makes them work much less than the optimizing households. Hence, the existence of these credit constrained households makes the aggregate labor supply increase less and weakens the response of markup driven by deep habits. However, effect of deep habits is not completely gone as price-inelastic term in equation (20) still remains. Hence, the labor demand curve shift upwards as firms reduce markup. These combined effects make it possible for real wage to rise more compared to the case without rule-of-thumb consumers. As a consequence, current labor income of rule-of-thumb consumers inreases and so does their current consumption. Adding this up to the flat consumption of deep habit forming Ricardian consumers makes the aggregate consumption positive.

In the model with deep habits in both government spending and consumption (row 1), when rule-of-thumb consumers are included, aggregate consumption becomes more positive relative to the case without them. This stems from the more amplified consumption of those consumers. Still, a large decline in markup makes this model inconsistent with the data. When there is no habits, contraction of consumption response is tempered relative to the model without rule-of-thumb consumers, as a result of partial offset by a rise in their consumption.

5.3 Sensitivity Analysis

In this section, we confirm the necessity of coexistence of deep habits and rule-of-thumb consumers by analyzing the sensitivity of the responses of consumption and markup to the key parameters of the model. Figure (3) illustrates how the choice of rule-of-thumb share λ shapes the initial reaction of the model keeping rest of the parameters fixed to the baseline. As depicted in the top panel, notable feature of the model with deep habits in both government spending and consumption is that consumption appears to be positive for all the range of λ. However, in the range below $\lambda = 0.3$, in which recent estimates are included, as λ becomes closer to 0, markup has to fall by a much larger extent than the amount considered in the literature (i.e. 0.5 percent) for an increase in consumption.

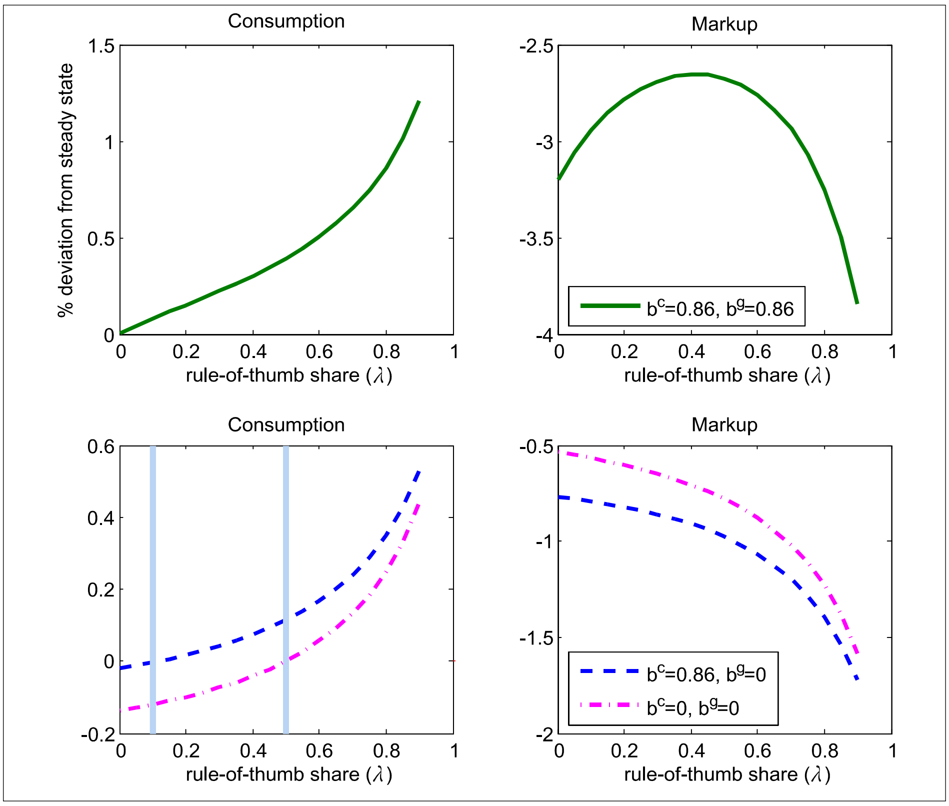
Although, assuming deep habits in government spending lacks empirical justification, it is interesting to examine the shape of markup as a funtion of λ in the sense it hints the relationship between deep habits and rule-of-thumb share. There are two opposite channels through which λ affects markup. First, as λ increases, the upward pressure in real wage becomes greater. Then, consumption of rule-of-thumb consumers surges more, raising aggregate demand. As a consequence, more output is generated by the production side and, therefore, markup declines more and more. Second, as discussed in secion 3, increase in λ makes it more difficult to generate fall in markup attained by deep habits. Note that, as λ increases, effect of first channel accelerates due to the amplification process by rule-of-thumb consumers. For positive λ, second channel prevails over the first for a while, then, after reaching a peak, the reverse happens as the force of the first channel is increasing in λ.

The bottom panel of Figure (3) reports how existence of deep habits (only in consumption) complements rule-of-thumb share. When no habits are assumed, the minimum value of rule-of-thumb share consistent with positive consumption is 0.5, which is recently deemed to be high. However, in the model with deep habits, positive response of consumption is realized when $\lambda = 0.1$. This value is well below its recent empirical estimates.[12] Hence, with any values of λ that are in the range of recent estimates, the model can produce positive consumption with

[12] Estimates of Coenen and Straub (2005) for rule-of-thumb share ($\lambda = 0.246$) is not enough to crowd in consumption in their estimated model of Galí et al. (2007).

analogous size of markup response to that given by the model with no habits.

[Figure 3] Initial response to a different values of λ

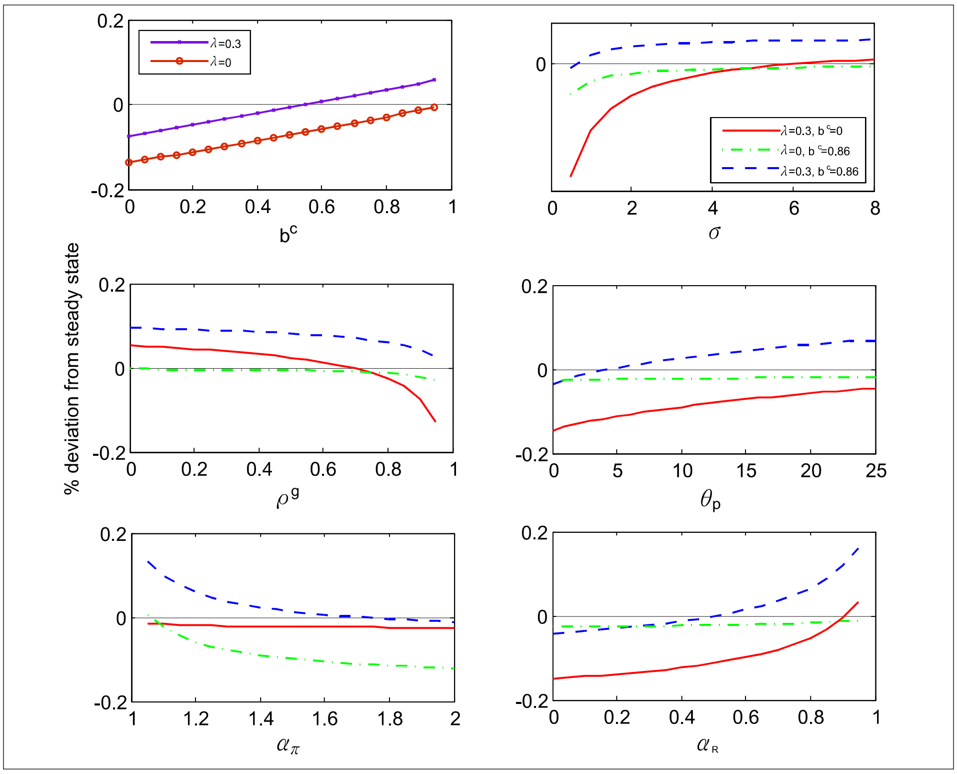


Note: Shaded area marks the minimum rule-of-thumb share for positive consumption.

The shape of markup to variation in λ is no longer arch-shaped under deep habits only in consumption. Comparing price-elastic term of equation (19) and (20), X_t^g is less than G_t. This means that the growth rate of price-elastic term of equation (19) is much larger than the counterpart in equation (20) after a rise in government spending shock at time t, implying more sensitive response of markup. As a consequence, the channel of λ influencing markup incurred by deep habits only in consumption is weaker than the case in deep habits both in government expenditure and consumption. Therefore, first channel always prevails over the second one, leading to downward-sloping shape, but less steeper than the case without habits, shown in bottom-right pannel.

Figure (4) summarizes the sensitivity of consumption to other key parameters considered to be important in the literature that studies the effect of government spending. Taking the model with rule-of-thumb consumers and deep habits only in consumption as the base, each graph shows the sensitivity varying paramater of interest. The top-left graph explores the sensitivity to the degree of deep habits. Notice that, in all the range of habit parameter, abstracting from rule-of-thumb consumers, deep habit model fails to predict positive response of consumption. In the top-right graph, within the range of coefficient of relative risk aversion, σ, that is generally estimated and calibrated (i.e. from 1 to 2), neither deep habits nor rule-of-thumb consumers produce procyclical consumption. Thus, the presence of rule-of-thumb consumers has to be associated with deep habits.

[Figure 4] Initial response of consumption to variations in selected variables



The middle-left graph shows the sensitivity as a function of persistence of government spending, ρ^g. Notice our conjecture that deep habits only do not generate plus consumption sign is robust to variation in ρ^g. Also, when there is strong wealth effect attained by high ρ_g, the model of rule-of-thumb consumers (i.e. real line), does not crowd in consumption. As portrayed in middle-right graph, each component separately turns out to be unsuccessful even with high degree of price stickiness. In contrast, only the combination of both components seems to have positive impact on consumption within the range that is generally viewed to be consistent with the micro evidence.

Finally, the bottom two panels illustrate the consequences of variations in the parameters of the monetary policy rule. Intuitively, large α_π and low α_R lead to a larger increase in real interest rate in response to high inflation induced by fiscal expansion. As a result, consumption of Ricardian consumers declines further, dampening the response of total consumption. We observe, for most values of α_π that lies in determinancy region, only interdependence of deep habits and rule-of-thumb consumers is conducive to cross the zero consumption line.[13]

VI. Conclusions

In the data, procyclical fluctuation in consumption and countercyclical movements in markup are the most prominent feature of the response to government spending shocks. Deep habits and rule-of-thumb consumers have been investigated respectively to explain this feature, but each of them cannot be fully supported empirically in the sense that the former induces counterfactually significant drop in markup and the latter admits a larger rule-of-thumb share than recent empirical estimates. The goal of this paper is to assess whether the coexistence of those two factors can improve the models that have been considering them seperately.

Our finding is that the deep habit model shapes different responses in key variables depending on specification of habits. Deep habits in both government expenditure and consumption succeed in predicting a rise in consumption, but lead to sizable fall in markup. In contrast, deep habits only in consumption, which is empirically relevant, reduce a decline in markup but crowd out consumption. Considering the key mechanism to explain positive consumption response relies on dominance of expansion in labor demand over an increase in labor suppy, we incorporate rule-of-thumb consumers in the model with deep habits only in consumption. The presence of rule-of-thumb consumers not only mutes the shift of labor supply but also works against the countercyclical markup induced by deep habits.

In this setting, consumption rises and markup shows weaker countercyclicality than the model with deep habits in both government spending and consumption (i.e. Ravn et al., 2006). Furthermore, compared to the model with no habits but with rule-of-thumb households (i.e. Galí et al., 2007), the fraction of those households necessary to see consumption go up is much smaller as additional expansion of labor demand due to the existence of deep habits allows labor supply to shift further.

[13] For detailed discussion regarding the equilibrium determinancy in New Keynesian model with deep habits can be found in studies by Zubairy (2013).

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Appendix

A. Complete Set of Symmetric Equilibrium Conditions

A symmetric competitive equilibrium is the sequence of 23 variables, $\{Y_t, R_t^k, MC_t, I_t, K_t, W_t, \Lambda_t, R_t, C_t, C_t^o, C_t^r, N_t, N_t^o, N_t^r, \Pi_t, x_t^c, x_t^g, s_t^c, s_t^g, \nu_t^c, \nu_t^g, g_t, \mu_t\}_{t=0}^{\infty}$, that solves the following system of 23 equations: equations from (21) to (41), the exogenous process for government spending, (13), and the monetary policy rule, (14).

$$X_t^c = C_t^o - b^c S_{t-1}^c \tag{21}$$

$$X_t^g = G_t - b^g S_{t-1}^g \tag{22}$$

$$K_{t+1} = (1-\delta)K_t + I_t \tag{23}$$

$$\Lambda_t = \frac{1}{X_t^{c^\sigma}} \tag{24}$$

$$\frac{\Lambda_t W_t}{\mu_t} = \gamma(1-N_t^o)^{-\chi} \tag{25}$$

$$C_t^r = W_t N_t^r - T_t^r \tag{26}$$

$$\frac{W_t}{\mu_t} = \gamma C_t^{r^\sigma}(1-N_t^o)^{-\chi} \tag{27}$$

$$1+\phi'\left(\frac{K_{t+1}}{K_t}\right) = E_t\beta\frac{\Lambda_{t+1}}{\Lambda_t}\left[R_{t+1}^k + 1 - \delta + \phi'\left(\frac{K_{t+2}}{K_{t+1}}\right)\frac{K_{t+2}}{K_{t+1}} - \phi\left(\frac{K_{t+2}}{K_{t+1}}\right)\right] \tag{28}$$

$$\left(1-\eta_w + \frac{\eta_w}{\mu_t}\right)N_t^o = 0 \tag{29}$$

$$\Lambda_t = R_t E_t \beta \frac{\Lambda_{t+1}}{\Pi_{t+1}} \tag{30}$$

$$\begin{aligned}\Pi_t\omega'(\Pi_t) &= (1-\eta_p + \eta_p MC_t)(C_t + I_t + G_t) \\ &\quad -\eta_p(\nu_t^c X_t^c + \nu_t^g X_t^g - (1-MC_t)((1-\lambda)C_t^o + G_t)) + E_t\beta\frac{\Lambda_{t+1}}{\Lambda_t}\Pi_{t+1}\omega'(\Pi_{t+1})\end{aligned} \tag{31}$$

$$v_t^c + (1-\lambda)(MC_t - 1) = E_t \beta \frac{\Lambda_{t+1}}{\Lambda_t} [\rho^c (v_{t+1}^c + (1-\lambda)(MC_{t+1} - 1)) + (1-\rho^c) b^c v_{t+1}^c] \quad (32)$$

$$v_t^c + (MC_t - 1) = E_t \beta \frac{\Lambda_{t+1}}{\Lambda_t} [\rho^{gg} (v_{t+1}^g + MC_{t+1} - 1) + (1-\rho^{gg}) b^g v_{t+1}^g] \quad (33)$$

$$Y_t = C_t + G_t + I_t + \omega(\Pi_t) + \phi\left(\frac{K_{t+1}}{K_t}\right) K_t \quad (34)$$

$$Y_t = K_t^{\alpha} N_t^{1-\alpha} - \vartheta \quad (35)$$

$$R_t^k = \alpha MC_t \left(\frac{K_t}{N_t}\right)^{\alpha - 1} \quad (36)$$

$$W_t = (1-\alpha) MC_t \left(\frac{K_t}{N_t}\right)^{\alpha} \quad (37)$$

$$S_t^c = \rho^c S_{t-1}^c + (1-\rho^c) C_t^o \quad (38)$$

$$S_t^g = \rho^{gg} S_{t-1}^g + (1-\rho^{gg}) G_t \quad (39)$$

$$C_t = (1-\lambda) C_t^o + \lambda C_t^r \quad (40)$$

$$N_t = (1-\lambda) N_t^o + \lambda N_t^r \quad (41)$$

B. Steady State

We define fixed cost $\vartheta = (\frac{1}{MC} - 1)Y$ to ensure capital income share to be equal to α in steady state. Rest of the parameters can be pinned down as follows.

$$R^k = \frac{1}{\beta} - 1 + \delta$$

$$\gamma_i = \frac{\alpha\delta}{R^k}, \quad \gamma_c = 1 - \gamma_g - \gamma_i$$

$$MC = 1 - \frac{1}{\eta_p(\lambda\gamma_c + \gamma_i + (1-\lambda)\gamma_c \frac{aa^c}{bb^c} + \gamma_g \frac{aa^g}{bb^g})}$$

$$\nu_c = \frac{(1-\lambda)(1-MC)}{bb^c}, \quad \nu_g = \frac{(1-MC)}{bb^g}, \quad X_c = Caa^c, \quad X_g = Gaa^g$$

$$aa^c = 1 - \frac{b^c(1-\rho^c)}{1-\rho^c}, \; aa^g = 1 - \frac{b^g(1-\rho^{gg})}{1-\rho^c}, \; bb^c = 1 - \frac{b^c(1-\rho^c)}{\frac{1}{\beta}-\rho^c}, \; bb^g = 1 - \frac{b^g(1-\rho^{gg})}{\frac{1}{\beta}-\rho^{gg}}$$

$$K = N\left(\frac{R^k}{\alpha MC}\right)^{\frac{1}{\alpha-1}}, \quad W = MC(1-\alpha)\left(\frac{K}{N}\right)^{\alpha}$$

$$Y = K^{\alpha}N^{1-\alpha} - \vartheta$$