

Re-thinking Price Stability in an Economy with Endogenous Firm Entry: Real Imperfections under Product Variety*

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Abstract

In this paper, we re-think price stability in an economy with endogenous firm entry under possible distortions. We first demonstrate that endogenous entry causes real imperfections. Reflecting fluctuations in the number of varieties, the gap between the natural and the efficient level of output is no longer constant and variant to shocks. As a result, the central bank faces a trade-off between stabilizing inflation and welfare-relevant output gap. Then, we show that this results in the non-zero optimal rate of inflation. We further check whether welfare can be enhanced by targeting welfare-based inflation instead of cross-sectional average inflation contrary to the previous findings. Simulations even with such distortions as unknown natural interest rate or no fiscal remedy for efficient non-stochastic steady states, however, support cross-sectional average inflation targeting although there may exist some small gains by referring also to welfare-based inflation rates. Incomplete stabilization may enhance welfare in an economy when agents cannot internalize the externality on the love for variety.

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1 Introduction

Reflecting growing interests in understanding the role of firm heterogeneity or endogenous variety in international trades as the seminal research by Melitz (2003) represents, macroeconomists also start considering consequences of incorporating firm dynamics in dynamic stochastic general equilibrium models. As noted in Bilbiie, Ghironi, and Melitz (2007), the standard assumption in a widely used monetary business cycle model as well summarized in Walsh (2003) and Woodford (2003) that monopolistically competitive firms can maintain positive profits without worrying about new entry should be considered to be unrealistic.¹ At the same time, empirical researches in trade theory demonstrate strong pro-cyclical behavior of net producer entry, that cannot be explained without firm dynamics. Therefore, it is quite reasonable to seek for a model that has more realistic assumption about firm dynamics and can explain the observed role of extensive margin in business cycles. Among several researches in line with this motivation, Bilbiie, Ghironi, and Melitz (2005) inquire into the nature of a dynamic stochastic general equilibrium model with free entry and show that the performance of such models evaluated by the implied second moment properties are at least as good as the traditional model with fixed number of varieties. Bilbiie, Ghironi, and Melitz (2006), on the other hand, search for normative implication of endogenous variety. They recommend policy institutions to preserve the optimal amount of monopoly profits when firm entry is costly. Marginal cost pricing remains efficient only when the required sales subsidies are financed with the optimal split of lump-sum taxation between households and firms. Bilbiie, Ghironi, and Melitz (2007), while summarizing main conclusions from above two papers, further show that inflation can act as a distortionary tax on firm profits and therefore be harmful to firm's incentive to create new goods. Similarly, Bergin and Corsetti (2005) analytically studies the role of stabilization policy in a model with free entry. They show that monetary policy should face an additional role of controlling the optimal number of entrants. Their conclusion, however, is that the optimal monetary policy rule obtained in the dynamic new Keynesian model without entry remains to be optimal even under endogenous variety. Monetary policy that aims at marginal cost pricing, namely cross-sectional average inflation,² remains

¹Usually, it is assumed that firms continuously exist within the unit mass between 0 and 1.

²Bergin and Corsetti (2005) and Bilbiie, Ghironi, and Melitz (2007) call the producer price index (PPI) and consumer price index (CPI). Former corresponds to the cross-sectional average price index. and the latter is the welfare-based price index. As you will see, since the Rotemberg (1982) type of adjustment cost is employed, there is no cross

optimal. On the other hand, reflecting recent actual increase in varieties, Broda (2004) suggests that “Measuring price changes accurately is central to the macroeconomic analysis used in conducting monetary policy. Various forms of bias in the consumer price index (CPI) have been documented in recent years, but a new form of bias tied to the introduction of new goods has only recently been explored empirically. Estimates of the ‘new goods’ bias suggest that CPI inflation has an upward bias of 0.3 percentage point.”

Why are there such different views on the targeting inflation? First, it may come from the assumption of central banks’ knowledge on the natural rate of interest, namely the Vicksellian interest rate. Considering the actual implementation of monetary policy, we usually rely on some instrument rules. Hence, accurate knowledge of the natural rate of interest is necessary for the conduct of optimal monetary policy. The natural rate of interest is determined by the growth rate of the real marginal utility from consumption, that is denominated by the welfare-based price index. Therefore, if the natural rate of interest is assumed to be perfectly known even under endogenous firm entry as in Bergin and Corsetti (2005) and Bilbiie, Ghironi and Melitz (2006, 2007), it is quite natural to recommend central banks to stabilize cross-sectional average inflation. The situation of perfect knowledge of the natural rate of interest, however, seems rather unrealistic.³ We check the usefulness of welfare-based inflation targeting when the natural rate of interest is unknown to central banks.

Second, it is debatable whether the fiscal policy to eliminate real imperfections is available or not. Although not focused in the previous researches in this area, a very intriguing point is that endogenous entry causes real imperfections, a concept that introduced by Blanchard and Gali (2007), if appropriate fiscal policy is unavailable. Reflecting fluctuations in the number of varieties, the gap between the natural (flexible) and the efficient (Pareto optimal) level of output is no longer constant and variant to shocks.⁴ For example, Bergin and Corsetti (2005) implicitly state this point as “However, the allocation in a flexible price equilibrium will not be in general Pareto optimal. There are three distortions in our economy: monopoly power in production, under or oversupply of varieties, and nominal rigidities. Correcting

dispersion of prices. However, I feel the naming of PPI and CPI somehow misleading. There exist CPI indices all over the world, but none reflects the number of varieties. The index is computed as the average across different goods. Furthermore, the naming of average inflation seems also confusing with historical average inflation as in Nessen and Vestin (2005)

³See, for example, Orphanides and Williams (2002).

⁴For the definition of the natural and efficient output, see Chapter 6 of Woodford (2003).

the first two distortions requires an appropriate set of taxes and subsidies. Only if these are in place, can monetary policy be effective in targeting the efficient allocation.” Similarly, Bilbiie, Gironi, and Melitz (2006) summarize the types of distortions in a flexible price model with endogenous variety. In addition to the standard markup intertemporal dispersion⁵ emerging even without nominal rigidity,⁶ there exist “markup intra-temporal dispersion” and “non-synchronization of consumer surplus and profit destruction.” Although we know how to tackle the first distortion by monetary policy, whether monetary policy can completely ignore the latter two distortions is not a trivial question. For example, Blanchard and Gali (2007) argue that “We focus on one such real imperfection, namely real wage rigidities. When the baseline new Keynesian model is extended to allow for real wage rigidities, the *divine coincidence* disappears, and central banks indeed face a trade-off between stabilizing inflation and the welfare-relevant output gap.” Previous researches, such as Bergin and Corsetti (2005), Bilbiie, Gironi, and Melitz (2006), and Bilbiie, Gironi, and Melitz (2007), conclude that central banks should target cross-sectional average inflation not welfare-based inflation, that even contains information on the number of variety, by ignoring such a trade-off by assuming an appropriate fiscal policy. In a realistic economy, however, it is almost impossible to distinguish the natural level of output from the efficient level of output. Furthermore, Bilbiie, Gironi, and Melitz (2006) note that “Importantly, since the wedges between the PE and CE are state-contingent, optimal policies aimed at closing these wedges will also be state contingent.” Yet, a state contingent fiscal policy with non-distortional tax is rarely available. Hence, it seems more natural to assume that central banks aim at stabilize the welfare-relevant output gap, namely the gap between actual and efficient output, instead of the conventional output gap, namely the gap between actual and natural output. In that case, monetary policy targeting welfare-based inflation may be able to increase welfare through incomplete stabilization. As we will see, real imperfections imply that inflation rates in the second best economy should not be fixed. Therefore, lack of stabilization of cross-sectional average inflation may result in higher welfare by using inflation as a tax to control the optimal number of firms. Thus, following Blanchard and Gali (2007), we inquire into the case when the central bank is the only institution to mitigate all distortions.

In this paper, we re-think price stability in an economy with endogenous firm entry. We first demonstrate that the endogenous entry causes real

⁵This and monetary policy on this distortion are well summarized in Walsh (2003) or Woodford (2003).

⁶This is coming from the endogenous elasticity of substitution stemming, for example, from the translog preference as in Feenstra (2003).

imperfections. Reflecting fluctuations in the number of varieties, the gap between the natural and the efficient level of output is no longer constant and variant to shocks. As a result, central banks face a trade-off between stabilizing inflation and stabilizing welfare-relevant output gap. Then, we show that this results in the non-zero optimal rate of inflation. We further check whether welfare can be enhanced by targeting welfare-based inflation instead of cross-sectional average inflation, contrary to the findings in Bergin and Corsetti (2005) and Bilbiie, Ghironi, and Melitz (2007), in two cases, namely when the natural rate of interest is unknown and the non-stochastic steady states are distorted. Simulations even with such distortions, however, support cross-sectional average inflation targeting although there may exist some small gains by further referring also to welfare-based inflation rates. Incomplete stabilization may enhance welfare in an economy when agents cannot internalize the externality on the love for variety.

The rest of the paper is structured as follows. In Section 2, we show our model used for inquiring into price stability under endogenous firm entry. Then, Section 3 demonstrates that an economy with endogenous variety indeed contains real imperfections when the appropriate fiscal policy is not available. Section 4 discusses price stability under endogenous firm entry. Three main results will be shown there. First, the optimal inflation rate under endogenous variety are usually non-zero. By manipulating inflation rates that act like a tax, central banks can correct sub-optimally high or low number of firms stemming from inability to endogenize externality. Second, even under the situation where the central bank cannot observe the natural rate of interest, it is optimal to target cross-sectional average inflation rather than welfare-based inflation rates. Third, such a policy remains still desirable even when non-stochastic steady states are distorted, Yet, some small gains from incomplete stabilization can be expected by targeting some weighted average of cross-sectional average inflation and welfare-based inflation rates. Finally, we summarize our main findings and state several future directions of research in Section 5.

2 Model

The model used in this paper is based on Bilbiie, Ghironi and Melitz (2005, 2006, and 2007). We examine cases with two different preferences,⁷ namely

⁷This can be treated as the production function rather than preferences. Under this specification, however, increased range of intermediate goods shows up as increasing returns to specialization. As there exist empirical problems concerning increasing returns to specialization and CES production function, we treat this as preference. For details on

CES preference as in Dixit and Stiglitz (1977) and Benassy (1996), and translog preference as in Feenstra (2003). The first preference is abbreviated as the CES_DS preference in this paper. Elasticity of substitution and benefit of additional products under these two specifications are first shown in this section. Then, we derive the equilibrium conditions in three cases, namely under (monopolistically) competitive equilibrium, the Pareto optimal equilibrium, and the Ramsey policy.

2.1 Preferences

2.1.1 CES

The aggregator (utility function) is expressed as follows:

$$C_t = N_t^{\xi - \frac{\theta}{\theta-1}} \left[\int_0^{N_t} C_t(h)^{1-\frac{1}{\theta}} dh \right]^{\frac{\theta}{\theta-1}}, \quad (1)$$

where h denotes the index for goods, C is the consumption, and N is the number of varieties. By minimizing the expenditure under the certain level of aggregate consumption, we can obtain the Hicksian demand function:

$$C_t(h) = N_t^{(\theta-1)(\xi - \frac{\theta}{\theta-1})} \left[\frac{P_t(h)}{P_t} \right]^{-\theta} C_t. \quad (2)$$

Substituting (2) into (1), the welfare-based price index is derived as the expenditure function:

$$P_t = N_t^{\frac{\theta}{\theta-1} - \xi} \left[\int_0^{N_t} P_t(h)^{1-\theta} dh \right]^{\frac{1}{1-\theta}}. \quad (3)$$

As obvious from (3), the price elasticity of demand ζ is constant as

$$\zeta_t^{CES} \equiv \frac{\partial C_t(h)}{\partial P_t(h)} \frac{P_t(h)}{C_t(h)} = \frac{\partial \log [C_t(h)]}{\partial \log [P_t(h)]} = \theta. \quad (4)$$

Hence, the markup under the flexible price equilibrium⁸ is also constant as:

$$\mu_t^{CES} \equiv \frac{\zeta_t^{CES}}{\zeta_t^{CES} - 1} = \frac{\theta}{\theta - 1}. \quad (5)$$

this point, see footnote 22 in Bilbiie, Ghironi, and Melitz (2006).

⁸As obvious from this equation, flexible price equilibrium is where there is no rigidity on cross-sectional average inflation rates, or no changes in markup.

Under the symmetric equilibrium, the benefit of additional product variety ρ is derived as:

$$\rho_t^{CES} \equiv \frac{P_t(h)}{P_t} = N_t^{\xi-1}, \quad (6)$$

and this can be also represented in the elasticity form as ε :

$$\varepsilon_t^{CES} \equiv \frac{\partial \rho_t}{\partial N_t} \frac{N_t}{\rho_t} = \frac{\rho'_t}{\rho_t} N_t = \xi - 1. \quad (7)$$

(6) and (7) demonstrate that ξ is the parameter for the taste for variety as shown in Benassy (1996). When $\xi > 1$, consumers obtain utility gain from additional variety. When $\xi = \frac{\theta}{\theta-1}$, namely the same as the markup as shown below, the preference collapses to the standard CES_DS, where the aggregator is defined as:

$$C_t = \left[\int_0^{N_t} C_t(h)^{1-\frac{1}{\theta}} dh \right]^{\frac{\theta}{\theta-1}}.$$

2.1.2 Translog

Since the explicit form of the utility function cannot be represented, derivation of elasticity of substitution among goods and benefits from new goods is not straightforward as shown in Feenstra (2003) in detail. We herewith only show the results.

Under translog preference, the price elasticity of demand is no more constant as:

$$\zeta_t^{TL} = 1 + \eta N_t, \quad (8)$$

where η is the parameter determining the price elasticity, and therefore, the markup under the flexible price equilibrium is expressed as:

$$\mu_t^{TL} \equiv \frac{\zeta_t^{TL}}{\zeta_t^{TL} - 1} = 1 + \frac{1}{\eta N_t}. \quad (9)$$

The benefit of additional product variety now becomes

$$\rho_t^{TL} = \exp \left(-\frac{1}{2} \frac{\tilde{N} - N_t}{\eta \tilde{N} N_t} \right), \quad (10)$$

where $\tilde{N}$ is the the total number of goods conceivably available, and in elasticity form:

$$\varepsilon_t^{TL} = \frac{1}{2\eta N_t} \quad (11)$$

2.2 Monopolistically Competitive Equilibrium

There are three agents in the economy, namely consumer, firms and the central bank. The former two agents are optimizing utility and profit respectively. On the other hand, the central bank sets nominal interest rates according to some instrument rule. The optimizing central bank is considered in the case of the Ramsey problem.

2.2.1 Consumer

The representative consumer maximizes the life time welfare $Welf$ as:

$$Welf_t = Util_t + \beta E_t Welf_{t+1}, \quad (12)$$

where β is the subjective discount factor and $Util$ is the instantaneous utility in the iso-elastic form as:

$$Util_t = \frac{C_t^{1-\sigma}}{1-\sigma} - \chi \frac{h_t^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}}, \quad (13)$$

where h is the hours worked, σ is the relative risk aversion, φ is the Frisch elasticity of labor supply and χ determines the size of the steady state labor supply. The maximization is subject to the nominal budget constraint:

$$\frac{B_{t+1}}{P_t} + \frac{V_t}{P_t} N_{H,t} x_{t+1} + C_t = (1 + i_{t-1}) \frac{B_t}{P_t} + \frac{(D_t + V_t)}{P_t} N_t x_t + \frac{W_t}{P_t} h_t, \quad (14)$$

where B is the nominal debt, V is the value of the firm, namely the stock price, N_H is the firms already existing at time t , x is the share of holdings of such a stock, i denotes the short-term nominal interest rate set by the central bank, D is the nominal dividend and W is the nominal wage. In aggregate, naturally, $B = 0$ and $x = 1$.

First order necessary conditions are:

$$C_t^{-\sigma} = \lambda_t, \quad (15)$$

$$\chi h_t^{\frac{1}{\varphi}} = \lambda_t w_t, \quad (16)$$

$$\lambda_t = \beta E_t \frac{\lambda_{t+1} (1 + i_t)}{1 + \pi_{t+1}^C}, \quad (17)$$

$$\lambda_t v_t N_{H,t} = \beta E_t \lambda_{t+1} (d_{t+1} + v_{t+1}) N_{t+1}, \quad (18)$$

where we define

$$w_t = \frac{W_t}{P_t},$$

$$\begin{aligned}
d_t &= \frac{D_t}{P_t}, \\
v_t &= \frac{V_t}{P_t}, \\
1 + \pi_t^C &= \frac{P_t}{P_{t-1}} = \frac{\rho_{t-1}}{\rho_t} (1 + \pi_t), \tag{19}
\end{aligned}$$

and

$$1 + \pi_t = \frac{p_t}{p_{t-1}}.$$

π is cross-sectional average inflation rates while π^C is welfare-based inflation rates. In this paper, we assume the exogenous destruction of firms as:⁹

$$N_t = (1 - \delta) (N_{t-1} + N_{E,t-1}). \tag{20}$$

Therefore, $\delta \times 100\%$ of existing firms are assumed to exit from the market every period. By using (20) and, by definition,

$$N_{H,t} = N_t + N_{E,t}, \tag{21}$$

where N_E is the firm which enter the market at time t , we can rewrite (18) as:

$$v_t = (1 - \delta) \beta E_t \frac{\lambda_{t+1}}{\lambda_t} (d_{t+1} + v_{t+1}). \tag{22}$$

Furthermore, under the assumption of the symmetric equilibrium,

$$C_t + v_t N_{E,t} = w_t h_t + d_t N_t, \tag{23}$$

where we again use (21).

2.2.2 Firm

Each firm in the monopolistically competitive market maximizes the value of the firm, namely

$$v_t + d_t,$$

subject to the demand y^D being equal to supply y :

$$y_t = y_t^D$$

⁹As will be discussed in the conclusion, the analysis under the endogenous firm destruction is our next research agenda.

where the value of the firms can be represented as the present discounted value of profit (dividend) by using pricing kernel,

$$v_t = E_t \sum_{t=0}^{\infty} [(1 - \delta) \beta]^t \frac{\lambda_{t+1}}{\lambda_t} d_{t+1},$$

the profit is subject to the Rotemberg (1982) type price adjustment cost:

$$d_t = \frac{p_t}{P_t} y_t^D - w_t h_t - \frac{\kappa}{2} \left(\frac{p_t}{p_{t-1}} - 1 \right)^2 \frac{p_t}{P_t} y_t^D, \quad (24)$$

the linear production function:

$$y_t = Z_t h_t, \quad (25)$$

and the demand condition from the monopolistic competition:

$$y_t^D = \left(\frac{p_t}{P_t} \right)^{-\zeta_t} (C_t + PAC_t),$$

where PAC is the resource used for costly price changes:

$$PAC_t = N_t pac_t = N_t \frac{\kappa}{2} \left(\frac{p_t}{p_{t-1}} - 1 \right)^2 \frac{p_t}{P_t} y_t^D$$

Therefore, we can first obtain the first order necessary condition through the maximization with respect to h :

$$MC_t = \frac{w_t}{Z_t}, \quad (26)$$

Since the individual price can be expressed as

$$p_t = \mu_t MC_t P_t,$$

(26) is transformed into

$$\frac{p_t}{P_t} = \rho_t = \mu_t \frac{w_t}{Z_t}. \quad (27)$$

μ is the markup under the nominal rigidity and obtained by maximizing the value of the firm with respect to p :

$$\mu_t = \frac{\zeta_t}{(\zeta_t - 1) \left(1 - \frac{\kappa}{2} \pi_t^2 \right) + \kappa \left[\pi_t (1 + \pi_t) - (1 - \delta) \beta E_t \frac{1 - \frac{\kappa}{2} \pi_t^2}{1 - \frac{\kappa}{2} \pi_{t+1}^2} \frac{N_t}{N_{t+1}} \pi_{t+1} (1 + \pi_{t+1}) \right]}, \quad (28)$$

where we use the conditions under the symmetric equilibrium,

$$Y_t^C \equiv C_t + PAC_t = N_t \frac{p_t}{P_t} y_t = N_t \rho_t y_t, \quad (29)$$

$$PAC_t = N_t pac_t = \frac{\kappa}{2} \pi_t^2 Y_t^C,$$

and

$$C_t = \left(1 - \frac{\kappa}{2} \pi_t^2\right) Y_t^C. \quad (30)$$

Under symmetric equilibrium, the profit is defined as follows:

$$d_t = \left(1 - \frac{1}{\mu_t} - \frac{\kappa}{2} \pi_t^2\right) \frac{Y_t^C}{N_t}. \quad (31)$$

Furthermore, firms that consider entering the market actually enter when the present discounted value of future profits is larger or at least as much as the fixed entry cost augmented by the labor income, namely $\frac{w}{Z} f_E$. As a result, we can obtain the free entry condition as below:

$$\frac{w_t}{Z_t} f_{E,t} = v_t. \quad (32)$$

2.2.3 Monetary Policy

First, we assume that the central bank sets short-term nominal interest rates with the target level of inflation being zero. We will conduct several simulations using very simple instrument rules except for cases under the Ramsey policy planner where the steady state inflation rate is non-zero. We examine two cases when the central banks know the natural (Vicksellian) rate of interest and it does not, with two possible references, namely cross-sectional average inflation rates and welfare-based inflation rates. Therefore, in total, we examine four simple instrument rules as follows.

When the natural rate of interest is unknown, if the central bank targets cross-sectional average inflation rates:

$$i_t = \frac{1 - \beta}{\beta} + \alpha \pi_t, \quad (33)$$

if it targets welfare-based inflation rates:

$$i_t = \frac{1 - \beta}{\beta} + \alpha E_t \pi_{t+1}^C. \quad (34)$$

Welfare-based inflation rates that refer to the predetermined variable, namely the current number of firms (varieties), cannot be stabilized completely by

central banks at the time when the shock hits the economy. Therefore, we employ the forecast based inflation targeting instrument rule when the central bank aims to stabilize the welfare-based inflation. On the other hand, when the natural rate of interest, defined as the real interest rate in the flexible price economy to be consistent with (17), namely $\frac{\lambda_t^* \pi_{t+1}^{C^*}}{\beta \lambda_{t+1}^*} - 1$, is known, if the central bank targets cross-sectional average inflation rates,

$$i_t = \left(E_t \frac{\lambda_t^* \pi_{t+1}^{C^*}}{\beta \lambda_{t+1}^*} - 1 \right) + \alpha \pi_t, \quad (35)$$

if it targets the welfare-based inflation rates:

$$i_t = \left(E_t \frac{\lambda_t^* \pi_{t+1}^{C^*}}{\beta \lambda_{t+1}^*} - 1 \right) + \alpha E_t \pi_{t+1}^C. \quad (36)$$

Since we only consider cases with complete stabilization, α is set to be very large. Therefore, monetary policy with (35) produces the flexible price equilibrium allocation.¹⁰

2.2.4 Monopolistically Competitive Equilibrium Model

A (monopolistically) competitive equilibrium model consists of 10 equations as below.¹¹

¹⁰The flexible price equilibrium in this paper shows the economy where there is no nominal rigidities on cross-sectional average inflation or no markup fluctuations.

¹¹Since the number of the firm is the only endogenous state variable, the model can be summarized to just a single equation.

$$\begin{aligned}
(\text{MCE1}): \quad & \zeta_t = \theta \text{ or } 1 + \eta N_t \text{ from (4) or (8)} \\
(\text{MCE2}): \quad & \rho_t = N_t^{\xi-1} \text{ or } \exp\left(-\frac{1}{2} \frac{\tilde{N}-N_t}{\eta \tilde{N} N_t}\right) \text{ from (6) or (10)} \\
(\text{MCE3}): \quad & Util_t = \frac{C_t^{1-\sigma}}{1-\sigma} - \chi \frac{h_t^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}} \text{ from (13)} \\
(\text{MCE4}): \quad & Wel f_t = Util_t + \beta E_t Wel f_{t+1} \text{ from (12)} \\
(\text{MCE5}): \quad & \frac{\rho_t}{\mu_t} f_{E,t} = (1-\delta) \beta E_t \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \left[\frac{\left(1 - \frac{1}{\mu_{t+1}} - \frac{\kappa}{2} \pi_{t+1}^2\right)}{\left(1 - \frac{\kappa}{2} \pi_{t+1}^2\right)} \frac{C_{t+1}}{N_{t+1}} + \frac{\rho_{t+1}}{\mu_{t+1}} f_{E,t+1} \right] \\
& \text{from (27), (32), (31), (30), (15) and (22)} \\
(\text{MCE6}): \quad & \chi h_t^{\frac{1}{\varphi}} = C_t^{-\sigma} Z_t \frac{\rho_t}{\mu_t} \text{ from (15), (27) and (16)} \\
(\text{MCE7}): \quad & N_{t+1} = (1-\delta) \left[N_t + \frac{Z_t h_t}{f_{E,t}} - \frac{C_t}{\rho_t f_{E,t} \left(1 - \frac{\kappa}{2} \pi_t^2\right)} \right] \text{ from (27), (20),} \\
& \text{(31), (32), (30) and (23)} \\
(\text{MCE8}): \quad & \mu_t = \frac{\zeta_t}{(\zeta_t-1)\left(1 - \frac{\kappa}{2} \pi_t^2\right) + \kappa \left[\pi_t(1+\pi_t) - (1-\delta) \beta E_t \frac{1 - \frac{\kappa}{2} \pi_t^2}{1 - \frac{\kappa}{2} \pi_{t+1}^2} \frac{N_t}{N_{t+1}} \pi_{t+1}(1+\pi_{t+1}) \right]} \\
& \text{from (28)} \\
(\text{MCE9}): \quad & \frac{C_t^{-\sigma}}{\beta E_t C_{t+1}^{-\sigma}} = \frac{1+i_t}{1+E_t \pi_{t+1}^C} \text{ from (15), (17), and (19)} \\
(\text{MCE10}): \quad & i_t = \frac{1}{\beta} + \alpha \pi_t, \frac{1}{\beta} + \alpha E_t \pi_{t+1}^C, \left(E_t \frac{\lambda_t^* \pi_{t+1}^{C*}}{\beta \lambda_{t+1}^*} - 1 \right) + \alpha \pi_t \text{ or} \\
& \left(E_t \frac{\lambda_t^* \pi_{t+1}^{C*}}{\beta \lambda_{t+1}^*} - 1 \right) + \alpha E_t \pi_{t+1}^C \text{ from (33), (34), (35) or (36)}
\end{aligned}$$

2.2.5 Monopolistically Competitive Flexible Price Equilibrium

Under the flexible price equilibrium, above model is further reduced to the system of 7 equations as follows.

$$\begin{aligned}
(\text{MCEF1}): \quad & \zeta_t = \theta \text{ or } 1 + \eta N_t \\
(\text{MCEF2}): \quad & \rho_t = N_t^{\xi-1} \text{ or } \exp\left(-\frac{1}{2} \frac{\tilde{N}-N_t}{\eta \tilde{N} N_t}\right) \\
(\text{MCEF3}): \quad & Util_t = \frac{C_t^{1-\sigma}}{1-\sigma} - \chi \frac{h_t^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}} \\
(\text{MCEF4}): \quad & Wel f_t = Util_t + \beta E_t Wel f_{t+1} \\
(\text{MCEF5}): \quad & \rho_t \frac{\zeta_t-1}{\zeta_t} f_{E,t} = (1-\delta) \beta E_t \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \left[\frac{1}{\zeta_{t+1}} \frac{C_{t+1}}{N_{t+1}} + \rho_{t+1} \frac{\zeta_{t+1}-1}{\zeta_{t+1}} f_{E,t+1} \right] \\
(\text{MCEF6}): \quad & \chi h_t^{\frac{1}{\varphi}} = C_t^{-\sigma} Z_t \rho_t \frac{\zeta_t-1}{\zeta_t} \\
(\text{MCEF7}): \quad & N_{t+1} = (1-\delta) \left(N_t + \frac{Z_t h_t}{f_{E,t}} - \frac{C_t}{\rho_t f_{E,t}} \right)
\end{aligned}$$

2.3 Pareto Optimal Allocation

Social planner maximizes household utility as defined in (12) and (13) by acknowledging the fixed entry cost. As shown in the resource constraint in

(29), the aggregate production function is now expressed as:

$$Y_t = Z_t N_t \rho_t h_t. \quad (37)$$

The social welfare being consistent with that of the representative consumer in (12) and (13) is optimized subject to (37) and (MCE7), the condition that determines the firm dynamics. From the first order conditions, we can obtain the intra-temporal optimality condition for labor:

$$C_t^{-\sigma} \rho(N_t) Z_t = \chi h_t^{\frac{1}{\varphi}}, \quad (38)$$

the intertemporal optimality condition for consumption:

$$C_t^{-\sigma} f_{E,t} \rho_t = (1 - \delta) \beta E_t C_{t+1}^{-\sigma} \left(f_{E,t+1} \rho_{t+1} + C_{t+1} \frac{\varepsilon_{t+1}}{N_{t+1}} \right), \quad (39)$$

and firm dynamics

$$N_{t+1} = (1 - \delta) \left(N_t + \frac{Z_t h_t}{f_{E,t}} - \frac{C_t}{\rho_t f_{E,t}} \right). \quad (40)$$

Therefore, the model under the Pareto optimal allocations is now expressed as follows.

- (PO1): $\zeta_t = \theta$ or $1 + \eta N_t$
- (PO2): $\rho_t = N_t^{\xi-1}$ or $\exp \left(-\frac{1}{2} \frac{\tilde{N} - N_t}{\eta \tilde{N} N_t} \right)$
- (PO3): $Util_t = \frac{C_t^{1-\sigma}}{1-\sigma} - \chi \frac{h_t^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}}$
- (PO4): $Welf_t = Util_t + \beta E_t Welf_{t+1}$
- (PO5): $C_t^{-\sigma} f_{E,t} \rho_t = (1 - \delta) \beta E_t C_{t+1}^{-\sigma} \left(f_{E,t+1} \rho_{t+1} + C_{t+1} \frac{\varepsilon_{t+1}}{N_{t+1}} \right)$ from (39)
- (PO6): $\chi h_t^{\frac{1}{\varphi}} = C_t^{-\sigma} Z_t \rho_t$ from (38)
- (PO7): $N_{t+1} = (1 - \delta) \left(N_t + \frac{Z_t h_t}{f_{E,t}} - \frac{C_t}{\rho_t f_{E,t}} \right)$ from (40)
- (PO8): $\varepsilon_t = \xi - 1$ or $\frac{1}{2\eta N_t}$ from (7) or (11)

2.4 Ramsey Policy

The allocations and prices under the Ramsey optimal monetary policy¹² can be obtained by maximizing the social welfare defined in (12) and (13) subject to 9 equations consisting of (MCE1) to (MCE9). By solving such a problem

¹²For the details of the Ramsey policy computed here, see Levin, Onatski, Williams and Williams (2005) and Christiano, Ilut, Motto, and Rostagno (2007).

by maximizing with respect to all the endogenous variables in the monopolistically competitive model including the short-term nominal interest rate controlled by monetary policy, we can obtain 10 new optimality conditions, most of which are those for Lagrangian multipliers on (MCE1) to (MCE9). We used the code working under the Dynare for the Ramsey policy routine used in Levin and Lopez-Salido (2003) and Levin, Onatski, Williams, and Williams (2005).

2.5 Allocations under Fixed Labor

To focus on particular distortions, we will examine the case with fixed labor supply. In that case, h is constant and set to be unity, while the optimality conditions such as (MCE6), (MCEF6) and (PO6) are eliminated.

2.6 Calibration

We employ the calibrated parameters examined in Bilbiie, Gironi and Melitz (2005, 2006, 2007) except for the newly introduced parameter, the coefficient on the inflation gap in the instrument rule, that are set to be very large for complete stabilization. They are set as in Table 1 below.

Parameter	Value	Description and Definitions
θ	3.8	Elasticity of substitution among goods
ξ	1.1, 2 or $\theta/\theta - 1$	Taste for variety ¹³
η	0.35323	Parameter for translog preference
β	0.99	Subjective discount factor
δ	0.025	Exogenous exit rate
$\tilde{N}$	100	Total number of goods conceivably available
σ	1	Intertemporal elasticity of substitution
φ	1	Frisch elasticity
κ	77	Rotemberg adjustment cost
χ	0.924272	Utility weight on labor
α	150	Monetary policy parameter
Z	1	Steady state technology level
f_E	1	Steady state entry cost

Table 1: Parameter values

¹³Significant difference emerges depending on whether ξ is larger than the markup or not. Therefore, we examine two cases for CES in Benassy (1996) specification.

3 Real Imperfections

Real imperfections are the concept that is defined by Blanchard and Gali (2007). Using the terminologies in Blanchard and Gali (2007), the Pareto optimal allocations and prices are called *efficient* while those under the flexible price equilibrium are defined *natural*. If the gap between natural and efficient output is constant, “stabilizing inflation is equivalent to stabilizing the welfare-relevant output gap.” This implies that if the gap is not constant and affected by monetary policy, there exist *real imperfections* where the central bank faces the trade-off between the stabilizing nominal and real variables.

In a standard new Keynesian model well summarized in Walsh (2003) and Woodford (2003), the difference between the efficient and natural is always constant and cannot be controlled by monetary policy through nominal interest rates. Therefore, it is optimal for central banks to aim at completely stabilizing inflation rates even under the distorted steady state when the appropriate fiscal policy is unavailable.¹⁴ For example, under the flexible price equilibrium with the CES_DS preference, the iso-elastic utility function in (13), the linear production function as (25), and the optimality condition for the labor supply, we can obtain the consumption level under the monopolistically competitive market C^{MCE} :

$$C_t^{MCE} = \left(\frac{\theta - 1}{\chi \theta} Z_t^{1+\frac{1}{\varphi}} \right)^{\frac{\varphi}{1+\varphi\sigma}}, \quad (41)$$

while the counter part in (41) under the Pareto optimal allocation C^{PO} is

$$C_t^{PO} = \left(\frac{1}{\chi} Z_t^{1+\frac{1}{\varphi}} \right)^{\frac{\varphi}{1+\varphi\sigma}}. \quad (42)$$

The log difference between C^{MCE} and C^{PO} is always constant as $\frac{\varphi}{1+\varphi\sigma} \log\left(\frac{\theta-1}{\theta}\right)$. Furthermore, clearly real interest rates do not have any influence on this difference since consumption is solely determined by the exogenous state variable.¹⁵ Therefore, irrespective of the economy is at the efficient steady state or not, the central bank should aim at stabilizing inflation rates since there exists no real imperfections in the standard new Keynesian model without a cost push shock. This property of the standard new Keynesian model is named as the *divine coincidence* by Blanchard and Gali (2007). We will show that this condition does not necessarily hold under the economy with endogenous variety.

¹⁴Cost push shock can be considered as the source of the real imperfections since it can make the real variables time-varying through the markup.

¹⁵(41) and (42) are policy functions.

3.1 Analytical Comparison

Contrary to the standard new Keynesian model, the case with firm entry is very intriguing concerning real imperfections. Except for the special case with the CES_DS preference, the economy shows real imperfections even only with a single shock that expands production frontier outwards. Following Bilbiie, Ghironi and Melitz (2006, 2007), we first explain three distortions that divert allocations under the monopolistically competitive flexible price equilibrium from those under the social planner's optimization. Then, we further show that even under monopolistic competition, if the preference is the CES_DS and the labor supply is fixed, the Pareto optimal allocations coincides with those under the monopolistically competitive flexible price equilibrium.

By comparing the equilibrium conditions under the monopolistically competitive flexible price equilibrium to those under the Pareto efficient allocation, we can find three differences. The first is the differences in the intra-temporal optimality conditions for the labor supply namely in (MCEF6) and (PO6):

$$(MCEF6): \quad \chi h_t^{\frac{1}{\varphi}} = C_t^{-\sigma} Z_t \rho_t \frac{\zeta_t^{-1}}{\zeta_t},$$

$$(PO6): \quad \chi h_t^{\frac{1}{\varphi}} = C_t^{-\sigma} Z_t \rho_t.$$

This distortion is coming from the existence of the markup under the monopolistically competitive flexible price equilibrium. As shown in detail in Bilbiie, Ghironi, and Melitz (2006), this reflects the different markups for different final products, namely consumption goods and leisure here. This implies the finding in Lerner (1934) that “If the social degree of monopoly is the same for all final products there is no monopolistic alteration from the optimum at all.” Intuitively, due to the differences in markups, some goods are consumed at sub-optimally high level while others are at sub-optimally low level. Therefore, differences in markup naturally cause the welfare loss. We call this “markup intra-temporal dispersion.”

Other two distortions can be found in the intertemporal optimality conditions, namely between (MCEF5) and (PO5) together with (PO8):

$$(MCEF5): \quad \rho_t \frac{\zeta_t^{-1}}{\zeta_t} f_{E,t} = (1 - \delta) \beta E_t \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \left[\frac{1}{\zeta_{t+1}} \frac{C_{t+1}}{N_{t+1}} + \rho_{t+1} \frac{\zeta_{t+1}^{-1}}{\zeta_{t+1}} f_{E,t+1} \right]$$

$$(PO5) \text{ with } (PO8): \quad C_t^{-\sigma} f_{E,t} \rho_t = (1 - \delta) \beta E_t C_{t+1}^{-\sigma} \left(C_{t+1} \frac{\xi-1}{N_{t+1}} + f_{E,t+1} \rho_{t+1} \right) \text{ or} \\ (1 - \delta) \beta E_t C_{t+1}^{-\sigma} \left(C_{t+1} \frac{1}{2\eta N_{t+1}^2} + f_{E,t+1} \rho_{t+1} \right)$$

As formally shown in the *theorem* 1 in Bilbiie, Ghironi, and Melitz (2006), both allocations coincide¹⁶ when markup is synchronized over time and across

¹⁶This is at least true for the non-stochastic steady state and dynamics in the linearized

goods¹⁷ and the consumer surplus and profit destruction effects are balanced. Bilbiie, Ghironi, and Melitz (2006) term the distortion concerning the first as “markup intertemporal distortion” and that for the second as “non-synchronization of consumer surplus and profit destruction.” As is obvious from (4), these two conditions are satisfied when the preference is the CES_DS, namely when the parameter of the taste for variety is equal to the markup. Intuitively, this implies that the gains from additional utility from another new goods is the same as the firm’s incentive to obtain profit by creating a new product. As we will see, if the former is larger (smaller), the economy ends up with sub-optimally low (high) number of firms.

Therefore, unless the preference is the CES_DS and the labor is fixed, there exists a wedge between the allocations under the monopolistically competitive flexible price equilibrium and the Pareto optimal equilibrium. Hence, the economy under firm dynamics can produce real imperfections. This gap can be time-varying and affected by monetary policy. We will check this in the subsection below.

3.2 Numerical Comparison

In this subsection, we first examine the case under exogenous labor supply to focus on the role of two distortions, namely markup intertemporal distortion and non-synchronization of consumer surplus and profit destruction. We will compare the paths from three preference specifications, namely the CES in Benassy (1996), the CES_DS and the translog, in four situations, namely, under the Pareto optimal, the Ramsey optimal, the flexible price, and welfare-based inflation stabilized allocations. The third one is the outcomes under the monopolistically competitive flexible price equilibrium or the monopolistically competitive equilibrium when the instrument rule is (35). The last allocation is computed under the monopolistically competitive equilibrium with monetary policy as (36). Since the only endogenous state variable considered in this paper is the number of firms, we only demonstrate dynamics of the number of varieties. We apply two shocks respectively on Z and f_E with autocorrelation of 0.9. We examine both productivity and efficiency gains as shocks. Corsetti, Martin, and Pesenti (2005) state that the former has direct effects on the marginal cost while the latter has indirect effects on the aggregate price index through the number of varieties. Therefore, we are interested in whether we can obtain robust results irrespective of shock nature.

system.

¹⁷For details, see footnote 18 of Bilbiie, Ghironi, and Melitz (2006).

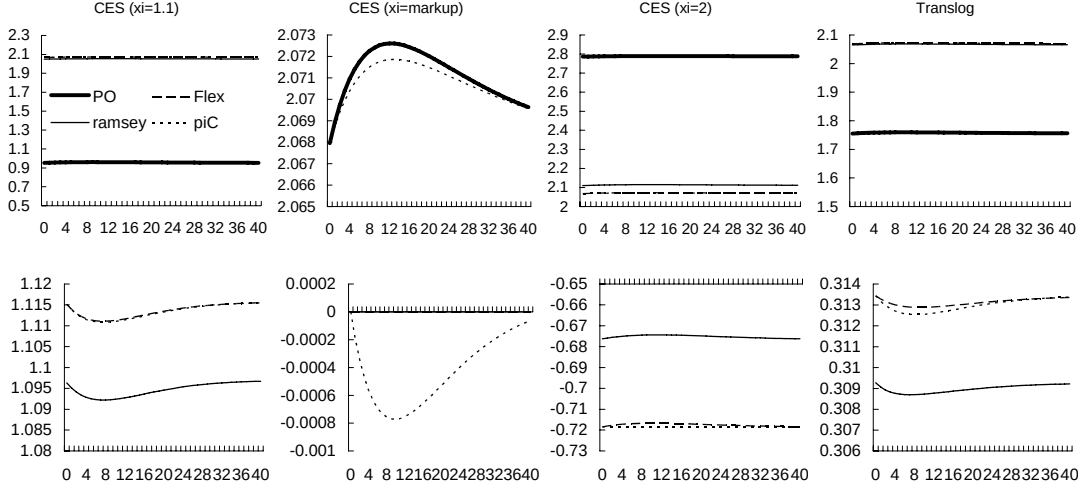


Figure 1: Productivity gain

3.2.1 Exogenous Labor Supply

Figure 1 below shows the level responses of the number of firms for the positive productivity gains, namely the standard positive TFP shock. Upper charts show the responses in the log level while lower charts demonstrate the (log) differences from the Pareto optimum equilibrium. There are several intriguing findings. First, if the taste for variety is larger (smaller) than the markup, there exist too few (many) firms or sub-optimally low (high) numbers of varieties in the economy. Mathematically, this can be understood by comparing the intertemporal optimality conditions as in the previous subsection. This is due to inability of agents to internalize the externality stemming from more variety. For example, although the utility gain from additional variety is very large when the taste for variety high, due to the constant markup on the consumer goods, sub-optimally low number of firms only find it optimal to enter the market. Second, with the translog preference, the number of firms is sub-optimally high in the competitive equilibrium. Bilbiie, Ghironi, and Melitz (2006) explain this as “The benefit of variety is only half the net markup for any N , so the competitive equilibrium features a sub-optimally high number of firms.” Third, when the preference is the CES_DS, as explained in the previous subsection, the Pareto optimal allocations coincide with those under the monopolistically competitive equilibrium and therefore those under the Ramsey optimal policy. Hence, it is optimal for the central bank to completely stabilize cross-sectional average inflation since the divine coincidence applies to this economy. Fourth and most importantly, except

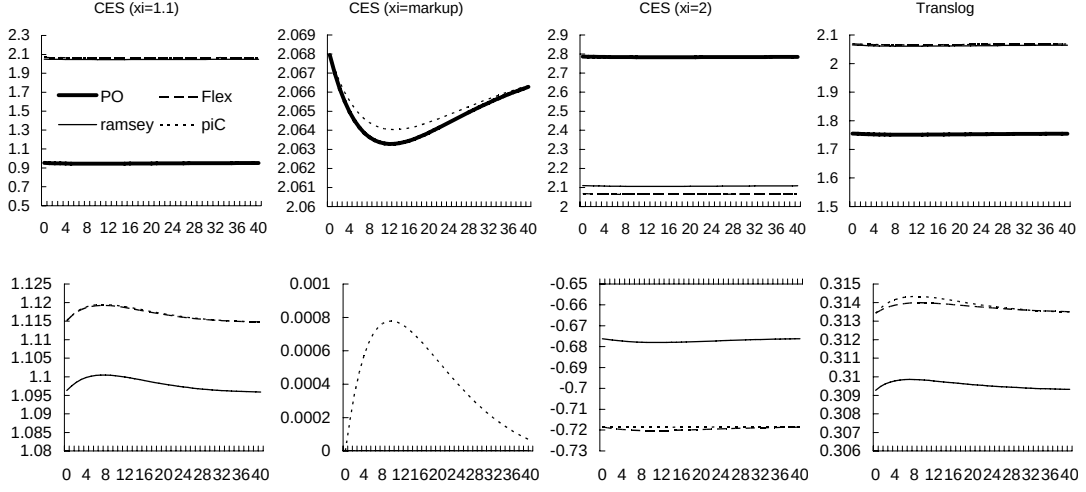


Figure 2: (Negative) Efficiency gain

for the case with the CES_DS preference, the Ramsey policy allocations are different from those under the flexible price equilibrium. Furthermore, the gap between the latter and the Pareto optimal allocation is time-varying. Since the steady states under the Ramsey policy are different from the complete inflation stabilization cases, we cannot say which of the two targeting schemes, namely cross-sectional average inflation or welfare-based inflation targeting, is better or not by just comparing the impulse responses to those under the Ramsey policy. At least, we can, however, say that the central bank faces a trade-off from some additional distortions that cannot be completely eliminated only by stabilizing cross-sectional average inflation rates. We will inquire into this more carefully in the next section.

Responses for the negative efficiency gains for entry, namely an increase in the entry cost, are shown in Figure 2 below. Almost similar results are obtained with this case. Depending on the preferences, the number of firms can be sub-optimally high or low and there seem to exist real imperfections except for the case with the CES_DS preference.

3.2.2 Endogenous Labor Supply

Here, to solely focus on the markup intra-temporal distortion, we only experiment the case with the CES_DS preference. Figure 3 below demonstrates the responses for both productivity and efficiency gains. The important finding here is that even when there is an additional distortion and the gap between the Pareto optimal equilibrium and the competitive equilibrium is

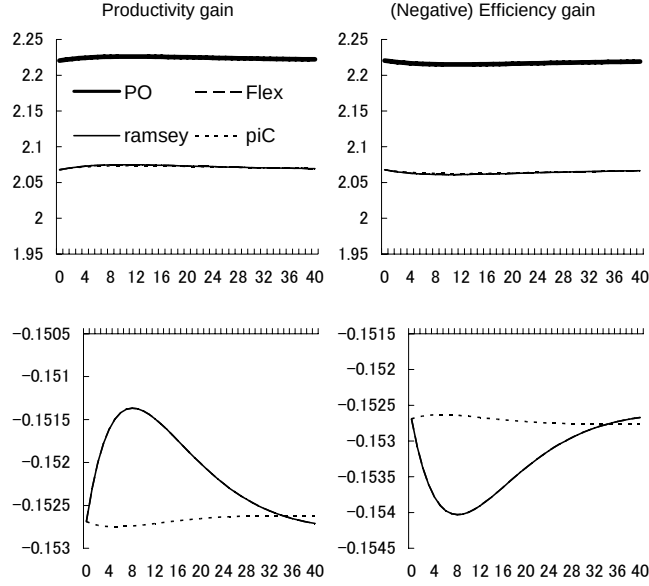


Figure 3: Endogenous labor supply

time-varying, responses under the Ramsey monetary policy is exactly the same as those under the flexible price. The markup intra-temporal distortion itself does not imply real imperfections at all for monetary policy. This is what Bergin and Corsetti (2005) show as “lack of stabilization is surely detrimental to welfare.” Hence, as the endogenous labor itself is not very intriguing for re-thinking price stability even under the distorted steady states, we will concentrate on the outcomes with the fixed labor supply in the analyses below.

4 Price Stability under Firm Entry

So far, we have seen that real imperfections likely occur in an economy with firm entry. Hence, monetary policy should play an additional role other than cross-sectional average inflation stabilization. Now, we are ready to scrutinize price stability in an economy with endogenous firm entry. First, we will show the optimal rate of inflation in an economy with endogenous variety under distorted non-stochastic steady states. Then, we would like to challenge the conclusion by Bergin and Corsetti (2005) and Bilbiie, Ghironi, and Melitz (2007) that central banks should aim to stabilize cross-sectional average inflation rather than welfare-based inflation rates from several different perspectives, namely from inability to monitor the natural rate of interest,

and from the distorted non-stochastic steady states stemming from unavailability of appropriate fiscal policy.

4.1 Optimal Rate of Inflation

Impulse responses in the previous section show that the steady states of the Ramsey optimal allocation are different from those under zero inflation steady states. This suggests that the optimal rate of inflation should be non-zero.¹⁸ The optimal inflation rates for three intriguing cases, namely with preferences except for the CES_DS, examined in the previous section are summarized as in the Table 2 below.

CES ($\xi = 1.1$)	CES ($\xi = 2$)	Translog
0.64%	-1.5%	0.26%

Table 2: Optimal inflation rate

The results show that when the number of firms is sub-optimally high (low), the optimal inflation rate in the second-best economy is positive (negative). This is because as mentioned in Bilbiie, Ghironi, and Melitz (2007), inflation acts as a tax on firm profits. (MCE7) clearly shows that the number of varieties becomes smaller when inflation rates are also higher. This becomes more evident if we look into (31). In this setting of the Rotemberg type adjustment cost, any positive inflation results in decrease in firm profits.¹⁹ Thus, in a situation where inflation results in some costs on profit, the steady state inflation is used as an instrument by the central bank to close the gap between the Pareto and the Ramsey optimal allocation. The central bank trade the welfare cost of inflation against the welfare cost of markup variations stemming from the misalignment of the benefit of extra variety with the profit incentives provided by markup. As noted in Bilbiie, Ghironi, and Melitz (2007), basically the model in this paper can be summarized in two equations as (MCE5) and (MCE7) in the monopolistically competitive equilibrium or (PO5) and (PO7) under the Pareto optimal allocations. The

¹⁸Possibly non-zero optimal inflation rate under the economy with firm entry without fiscal remedy is not a new idea. It is mentioned already mentioned in Bilbiie, Ghironi, and Melitz (2007) that “The (Ramsey) optimal rate of inflation would be non-zero in a second-best environment in which lump-sum instruments are unavailable. The monetary authority would trade the welfare cost of inflation against the welfare costs of markup variation coming from both a time-varying elasticity of substitution and the misalignment of the benefit of extra variety with the profit incentive provided by markup.”

¹⁹Note that if firms acknowledge the trend inflation and pay no cost in the price changes according to the trend inflation, the optimal inflation remains zero.

steady state values for the number of variety and consumption in the former are now expressed as :

$$N = \left[\frac{1 - (1 - \delta) \beta}{(1 - \delta) \beta \mu \left(1 - \frac{1}{\mu} - \frac{\kappa}{2} \pi^2 \right)} + \frac{\delta}{1 - \delta} \right]^{-1}, \quad (43)$$

and

$$C = \left(1 - \frac{\kappa}{2} \pi^2 \right) \left[N^{\xi-1} - \frac{\delta}{1 - \delta} N^{\xi} \right], \quad (44)$$

while those for the latter are

$$N = \left[\frac{1 - (1 - \delta) \beta}{(1 - \delta) \beta (\xi - 1)} + \frac{\delta}{1 - \delta} \right]^{-1}, \quad (45)$$

and

$$C = N^{\xi-1} - \frac{\delta}{1 - \delta} N^{\xi}, \quad (46)$$

where we substitute steady state benefits of additional product variety under the CES preference. Clearly, with the CES_DS preference, zero inflation results in the same allocations. With the CES preference in Benassy (1996),²⁰ however, if the Ramsey planner try to increase (decrease) the number of firms to the level in the Pareto optimal allocation by setting negative (positive) steady state inflation, it ends up with sub-optimally high (low) consumption as shown in (44). Compared to the fiscal prescriptions raised in Bilbiie, Ghironi, and Melitz (2006) that directly work through (MCE5) or (43), the term for the allocation of resources for costly prices changes in (MCE7) or (44) makes the central bank to face such a trade-off. Although it seems to have huge negative deflation can increase the number of variety, consumption and therefore welfare, it would results in lower markup as in (MCE8) so that the number of firms could also become lower. As a result, by facing the trade-off between inflation stabilization and the misalignment of taste for variety and profit incentive, the central bank as the Ramsey planner chooses some optimal level of steady state inflation. This new channel of the role of the steady state inflation rate is absent in the standard new Keynesian model with fixed variety.

This story is quite similar to the justification of the positive capital income tax rate when the asset market is incomplete. As shown by Aiyagari (1995), agents save more under the Bewley (1977) type economy since they need to prepare for the uninsured idiosyncratic shocks by self-insurance. As a result,

²⁰Similar results hold for the case with the translog preference.

a positive capital income tax rate reduces the sub-optimally high capital level and is therefore welfare-enhancing. In our model, the only endogenous state variable is the number of firms while it is capital in Aiyagari (1995). In both cases, sub-optimally high level of state variables can become smaller by introducing the tax on the profit.

From the perspective of inability in endogenizing the externality, this results can also be considered analogous to Ljungqvist and Uhlig (2000) and Choudhary and Levine (2006). They show higher tax rate is optimal since agents cannot internalize the externality stemming from external habit, namely the catching up with Joneses type preference.

The analysis in this subsection suggests that it is of great importance for the central bank to acknowledge whether the level of the aggregate endogenous state variables is sub-optimally high or low. Depending on this results, the optimal inflation rate as a tax device should become quite different.

4.2 Cross-sectional Average Inflation versus Welfare-based Inflation

It seems to become a consensus that monetary policy in an economy with firm dynamics should also stabilize cross-sectional average inflation instead of welfare-based inflation rates. Bergin and Corsetti (2005) conclude that “the goal of (welfare-based) CPI stability may not be a good target for policy makers. To the extent that it is desirable to support a flex price allocation, monetary authorities should stabilize firms’ marginal costs and product prices, not the CPI. The price level should instead move freely with entry, providing information about fluctuations in consumption utils which - given prices- households enjoy.” Similarly, Bilbiie, Ghironi, and Melitz (2007) insist that “Optimal monetary policy stabilizes producer prices but lets the consumer price index vary to accommodate changes in the number of available products.” On the other hand, reflecting the recent increase in varieties,²¹ Broda (2004) suggests that “Measuring price changes accurately is central to the macroeconomic analysis used in conducting monetary policy. Various forms of bias in the consumer price index (CPI) have been documented in recent years, but a new form of bias tied to the introduction of new goods has only recently been explored empirically. Estimates of the ‘new goods’ bias suggest that CPI inflation has an upward bias of 0.3 percentage point.”

What is the source of these different views on monetary policy in an economy with endogenous variety? There exist two possible explanations for these divergent views. The first is concerning the actual implementation of

²¹For details in this empirical finding, see Broda and Weinstein (2006).

monetary policy. What Bergin and Corsetti (2005) and Bilbiie, Ghironi, and Melitz (2007) recommend when the tax policy is available to eliminate the real imperfections is that monetary policy should stabilize markup fluctuations. Although how to implement such a policy through an interest rate rule is mentioned in Bilbiie, Ghironi, and Melitz (2007), the central bank is assumed to have complete knowledge about the natural rate of interest, that is the real interest rate in the flexible price equilibrium. Under such circumstances, it is quite natural that the central bank should solely stabilize cross-sectional average inflation rates. The most important reason why the central bank should possibly target welfare-based inflation is to precisely know the pricing kernel, namely the marginal utility out of consumption denominated by welfare-based inflation, that determines the natural rate of interest. Therefore, in the first experiment in this subsection, we consider the case without any real imperfections in non-stochastic steady states where the allocations under the social planner coincides with those under competitive market equilibrium. That is the case with fixed labor under the CES_DS preference where monetary policy is the sole source of dynamic distortions. It should be very difficult for central banks to have complete knowledge about the pricing kernel that reflects the number of firms under the flexible price equilibrium. Therefore, in this experiment, it is assumed that the central bank has knowledge only about the steady state real interest rate, that is $(1 - \beta)/\beta$ as in (33) and (34).

The second possibility is on the realistic implementation of the public policy. It is mentioned in Bilbiie, Ghironi, and Melitz (2006) that “Importantly, since the wedges between the PE and CE are state-contingent, optimal policies aimed at closing these wedges will also be state contingent.” Although some optimal tax policy turns out to be not state-contingent, realistically it is still questionable whether the fiscal authority can actually implement such a policy with non-distorting lump sum taxation. Therefore, in the second experiment, we check which inflation the central bank should stabilize, the cross-sectional average inflation versus the welfare-based inflation, by setting the steady state inflation at its Ramsey optimal level. Welfare-based inflation stabilization means lowering nominal interest rates when the number of firms increases. Therefore, it does not necessarily imply the control of the optimal number of firms. Monetary policy targeting welfare-based inflation can, however, increase welfare through incomplete stabilization. Real imperfections imply that inflation rates in the second best economy should not be fixed at some targeted level. Inflation rates as a tax can be used by the Ramsey policy planner, namely the central bank, as a tool to control the number of firms so that the economy becomes closer to the Pareto optimal situation. Therefore, lack of stabilization of cross-sectional average inflation

may result in higher welfare.

4.2.1 Efficient Steady States

If the central bank cannot observe the natural rate of interest, there is a possibility welfare-based inflation targeting can be welfare-enhancing since the welfare-based price level contains information on the pricing kernel. As shown in (35), under the symmetric equilibrium, the optimal interest rate rule in an economy with efficient steady states incorporates the dynamics of welfare-based inflation albeit in the flexible price equilibrium. Therefore, (34),²² that is the expected welfare-based inflation targeting rule to be consistent with the stochastic discount factor, can mitigate real imperfections better than the stabilization policy on cross-sectional average inflation as in (33).

First, we compute the welfare as the value in stochastic steady states in a second order approximated model.²³ The Table 3 below shows the welfare in both rules as (33) and (34) for 100,000 sample in each first five seed in Dynare when the size of one percentage standard error is given.

seed	Productivity gain		Efficiency gain	
	π	π^C	π	π^C
1	51.229	51.227	51.204	51.204
2	51.218	51.217	51.211	51.211
3	51.202	51.202	51.222	51.220
4	51.217	51.216	51.211	51.211
5	51.205	51.205	51.220	51.219

Table 3: Welfare comparison

In all cases examined here, welfare is higher with the standard stabilization policy on cross-sectional average inflation rates even though the natural rate of interest is unknown. Figure 4 below shows the responses for the productivity gain for different instrument rules. Again, upper charts show the responses in the log level while lower charts demonstrate the (log) differences from the Pareto optimum equilibrium. We can clearly monitor that responses under the flexible price equilibrium is very close to those obtained under the social planner's optimization. Although a slight departure from

²²Another possible specification is that including lagged nominal interest rates, usefulness of which is stressed in Orphanides and Williams (2002).

²³We solve this problem using Dynare. Following Kim and Kim (2007), we approximate all equations including the welfare measure up to the second order. For details, see Kim, Kim, Schaumburg, and Sims (2003) and Schmitt-Grohe and Uribe (2004).

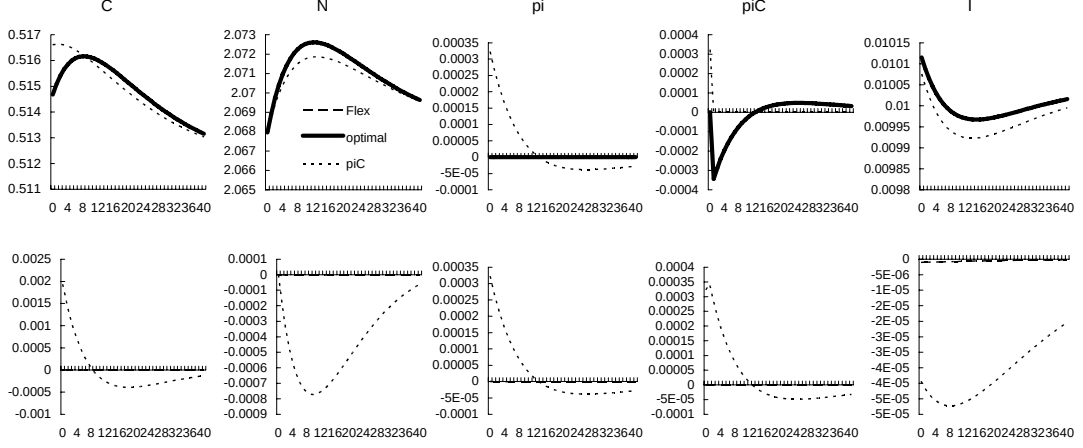


Figure 4: Productivity gain

the Pareto optimal equilibrium can be found, for example, in responses in nominal interest rates, it is minuscule and the departure in the same direction is much worse under the welfare-based inflation stabilization than under the cross-sectional average inflation stabilization. Similar results can be observed in Figure 5 below. Again, allocations and prices under the flexible price equilibrium are much closer to those under the social planner's optimization problem. Yet, lower charts show that the direction of the log differences from the Pareto optimal allocation is different in nominal interest rates. This shows a welfare-deteriorating effects of strict cross-sectional average inflation targeting in an economy with unknown natural rate, but the gain from further referring to welfare-based inflation is very minuscule. This result implies that the relative weights on welfare-based inflation, namely the power $1/(\theta - 1)$ in (19), may be sub-optimally high. As the weight on the firm dynamics becomes smaller with larger θ in (19), targeting welfare-based inflation can be more welfare-improving when goods are very much substitutable. We will inquire into this point in the next subsection as well.

4.2.2 Ramsey Steady State

As analyses in previous chapter show, due to non-zero steady state inflation, steady states under the Ramsey policy planner are different from those under both zero inflation stabilization rules. To be able to compare those response so that we can learn whether the central bank should target cross-sectional average or welfare-based inflation rates, we alter the instrument rules in (33)

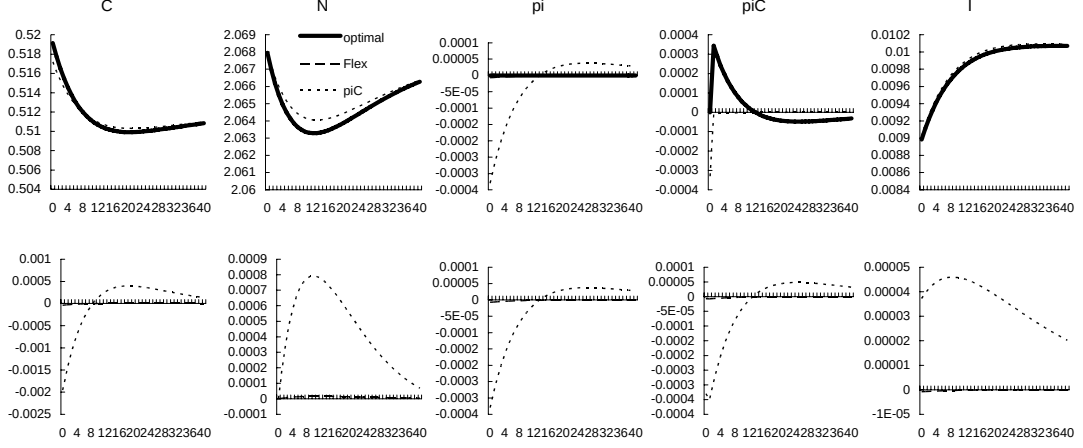


Figure 5: (Negative) Efficiency gain

and (34) as follows:

$$i_t = \frac{1 - \beta}{\beta} + \pi^{RO} + \alpha (\pi_t - \pi^{RO}),$$

and

$$i_t = \frac{1 - \beta}{\beta} + \pi^{RO} + \alpha E_t (\pi_{t+1}^C - \pi^{RO}),$$

where π^{RO} is optimal inflation rates under the Ramsey social planner.²⁴ The influential researches on the optimal monetary policy by Benigno and Woodford (2005) and Schmitt-Grohe and Uribe (2006) recommend the central bank to find out the optimal monetary policy around the steady state under the Ramsey policy. Hence, we evaluate the validity of above two instrument rules by testing which inflation targeting rule, namely cross-sectional average inflation or welfare-based inflation targeting, is closer to the pass suggested by the Ramsey policy planner.

CES ($\xi = 1.1$) Figure 6 below shows the responses for the productivity gain. Again, upper charts show the level responses in logs while lower charts demonstrate the (log) differences from variables under the Pareto optimal policy. Interestingly, inflation is not fixed even in the Ramsey policy. This implies real imperfections. Since the CES preference means a constant markup, the non-synchronization of consumer surplus and profit destruction alone makes the central bank to face a trade-off between stabilizing real and

²⁴ Almost no differences are found even if we use the specifications as in (35) and (36).

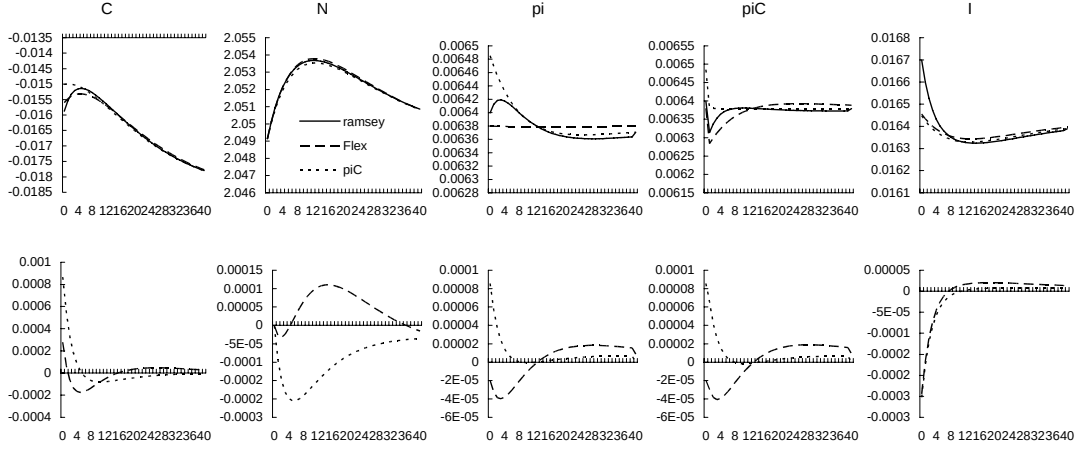


Figure 6: Productivity gain

nominal variables. As analyzed in the section for real imperfections, efficient allocation cannot be achieved since the intertemporal optimality conditions are different in the social planners problem and in the competitive equilibrium as shown in (MCEF5) and (PO5). Bilbiie, Gironi, and Melitz (2006) show that some tax policies can change the relationship in (MCEF5) directly so that it becomes the same as (PO5). In such a situation, the optimal policy is complete stabilization of cross-sectional average inflation rates. The correction of the steady state inflation here does, however, not have direct effects on intertemporal optimality conditions. It works through the firms dynamics via profits in (MCE5). Furthermore, we can not reach the Ramsey optimal allocations just by manipulating steady state inflation as shown in detail in (43) to (46). Hence, central banks makes inflation rates fluctuate so that it can control the number of firms to be close to the Pareto optimal allocations. As a result, the Ramsey policy implies the fluctuating inflation. As this is indeed coming from real imperfections, the story here is very much analogous to trade-offs analyzed in Faia and Monacelli (2007) under the financial market imperfections and in Faia (2006) under the labor market frictions, and in open economies where “when financial markets are incomplete, and when there is only partial pass-through from exchange rate to prices” as summarized in Rogoff (2006).

More importantly, allocations and prices under the flexible price equilibrium are more similar to those under the Ramsey planner. Therefore, in accordance with previous researches, a policy aiming at reaching to the flexible price equilibrium is better in welfare than that to stabilize welfare-based inflation. Yet, at the same time, movements under the Ramsey policy

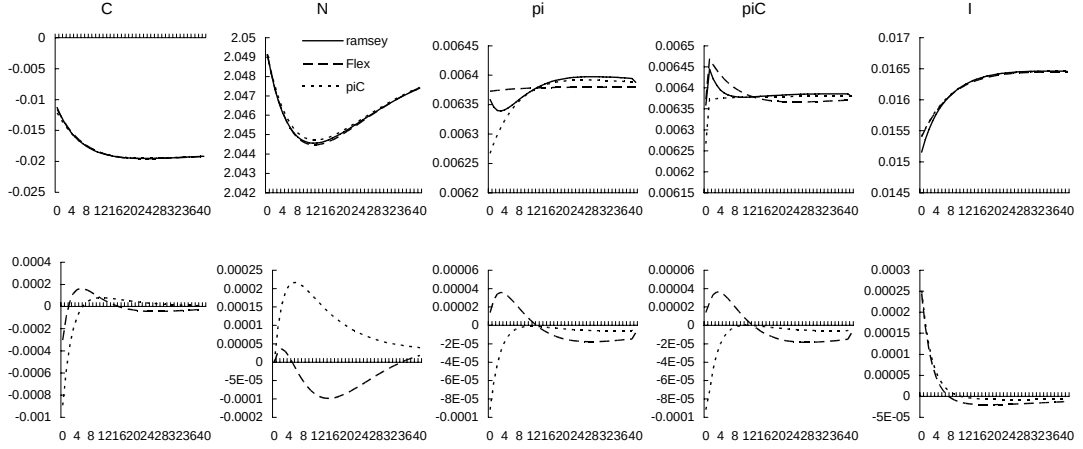


Figure 7: (Negative) Efficiency gain

is somewhere between those under cross-sectional average and those under welfare-based inflation targeting. Similar to the last case in the analysis above suggests, the weight in the instrument rule, namely $\frac{1}{\theta-1}$, seems to be too large for welfare-based inflation to be targeted.

Figure 7 below shows the responses to the negative efficiency gain. As stated above, by targeting cross-sectional average inflation, the economy becomes closer to the one under the Ramsey policy planner. Central banks may, however, gain by targeting the weighted average of cross-sectional average inflation and welfare-based inflation rates.

CES ($\xi = 2$) The responses in the CES preference when the taste for variety is high is shown as in Figure 8 and 9 below. These two charts also support the welfare dominance of the stabilization policy on cross-sectional average inflation.

Translog Figures 10 and 11 are responses under translog preference. Again, similar to the case with the CES preferences, flexible price allocations and prices are much more similar to those under the Ramsey policy planner. Yet, there may exist possible welfare gains from additionally referring to welfare-based inflation.

Results in these experiments under the Ramsey steady states suggest that the Ramsey policy is almost the same as cross-sectional average inflation stabilization. Yet, central banks may be able to increase welfare by targeting the mixture of cross-sectional average inflation and welfare based inflation

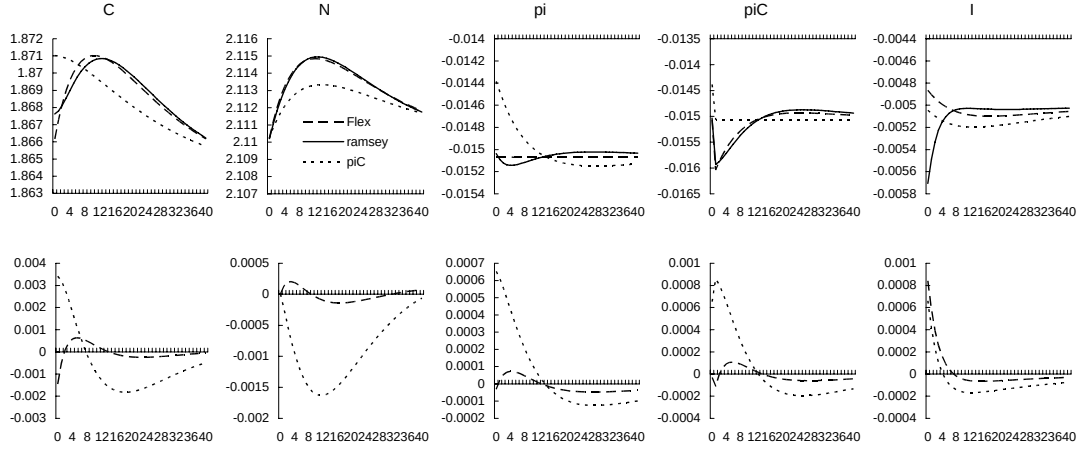


Figure 8: Productivity gain

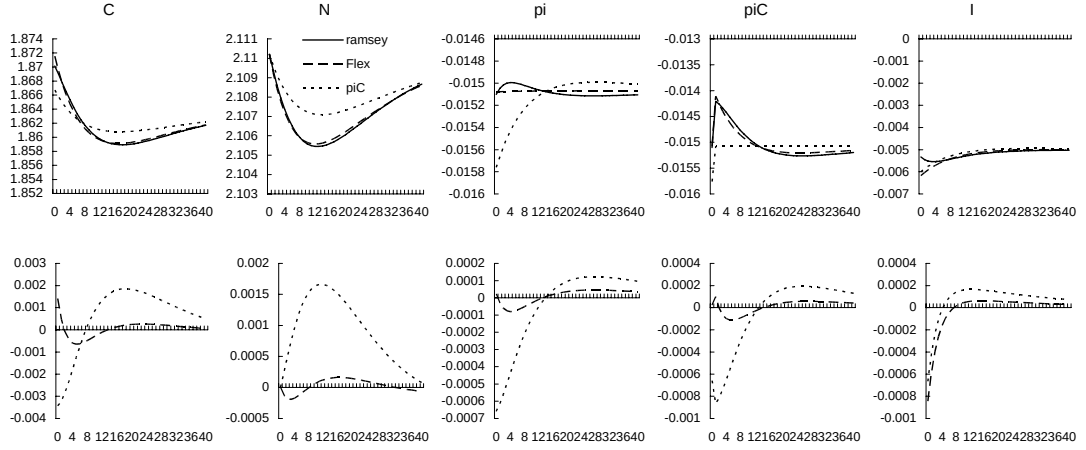


Figure 9: (Negative) Efficiency gain

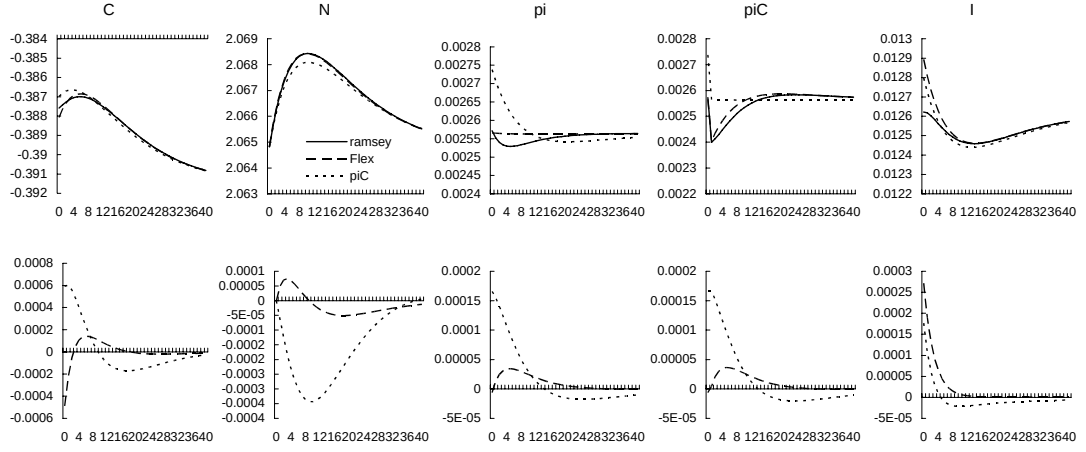


Figure 10: Productivity gain

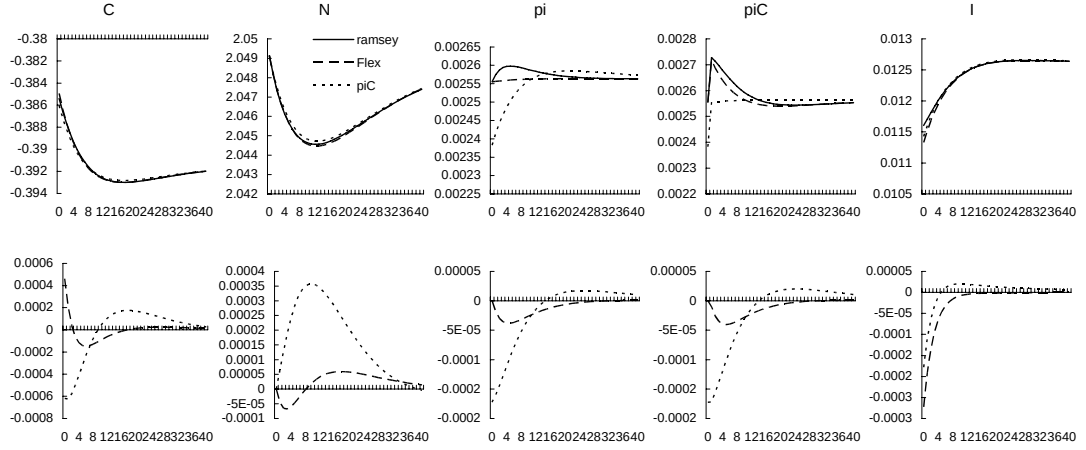


Figure 11: (Negative) Efficiency gain

rates. Although welfare-based inflation stabilization does not necessarily imply the control of the optimal number of firms, monetary policy referring also to welfare-based inflation can, however, increase welfare through incomplete stabilization. Inflation rates as a tax can be used by the Ramsey policy planner, as a tool to control the number of firms so that the economy becomes closer to the Pareto optimal situation. Therefore, lack of stabilization of cross-sectional average inflation may result in higher welfare. Overall, however, we see that such gains should be very small. As the weight on the firm dynamics in welfare-based inflation as shown in (19) becomes smaller with larger θ , the usefulness of welfare-based inflation targeting could become larger when the goods are very much substitutable. This is quite natural but at the same time very ironic result, since with higher θ , welfare-based inflation targeting becomes closer to cross-sectional average inflation targeting.

5 Conclusion

In this paper, we re-think price stability in an economy with endogenous firm entry. We first demonstrate that the endogenous entry causes real imperfections introduced in Blanchard and Gali (2007). Reflecting fluctuations in the number of varieties, the gap between the natural and the efficient level of output is no longer constant and variant to shocks. As a result, central banks face a trade-off between stabilizing inflation and stabilizing welfare-relevant output gap. Then, we show that this results in the non-zero optimal rate of inflation. We further check whether welfare can be enhanced by targeting welfare-based inflation instead of cross-sectional average inflation contrary to the findings in Bergin and Corsetti (2005) and Bilbiie, Ghironi, and Melitz (2007), in two cases, namely when the natural rate of interest is unknown and the non-stochastic steady states are distorted. Simulations even with such distortions as unknown natural rate or no fiscal remedy for efficient non-stochastic steady states, however, support cross-sectional average inflation targeting although there may exist some small gains by further referring also to welfare-based inflation rates. Incomplete stabilization may enhance welfare in an economy when agents cannot internalize the externality on the love for variety.

Future direction is to extend this research by endogenizing the firm destruction as examined in Melitz (2003) and Ghironi and Melitz (2005).²⁵ As less productive firms exit from the market, monetary policy may be able control the aggregate productivity by controlling the number of firms by altering

²⁵This extension could result in much more volatile movements in flexible price equilibrium. Therefore, the trade-off could be more evident.

inflation rates. Monetary policy can have direct effects on aggregate technology. In a discussion on Levin, Onatski, Williams, and Williams (2005), it is written that “Justin Wolfers wondered about the possibility of monetary policy having long-run effects. Specifically, he noted that if the natural rate of unemployment is itself a function of policy, there could be deep welfare costs.” Furthermore, Kocherlakota (2007) demonstrates, by using the optimal tax problem under non-testable assumption about how stochastic shock to the labor-supply curve co-vary with tax rates, that “a model that fits the available data perfectly may provide worse answers to policy questions than an alternative” and “this kind of estimation is only useful if we have reliable a priori evidence about the shock process.” Analyses on monetary policy under models with endogenous exit may bring us very interesting implications concerning on the relationship between monetary policy and technology as above arguments suggest.

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