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Heterogeneous Price Rigidity, Durable Goods, and Optimal Monetary Policy*

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Abstracts

This paper studies optimal interest rate feedback rule in an economy with heterogeneous price rigidity and durable goods. Many literatures document that the price of durable goods is more flexible than that of nondurable goods. Our analysis builds on the New Keynesian framework where nondurables price is sticky and durables price is flexible. Our findings about the optimal interest rate feedback rule in the model can be explained as follows: Firstly, the optimal interest rate feedback rule yields the level of welfare close to that under the Ramsey optimal policy even in this model. In addition, the primary feature of the optimal rule is responding to sticky-price inflation only, rather than aggregate price inflation. This is because there does not exist a trade-off between stabilizing sticky nondurable goods price inflation and following the Ramsey optimal path of each sectoral output. However, responding to aggregate price inflation causes larger welfare loss through the distortion of the relative price of durable goods.

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Ⅰ. Introduction

The inclusion of a durable goods sector in a New Keynesian model has significant implications for monetary policy. Recent literatures which are based on New Keynesian models have explicitly included the consumption of durable goods as an important component. A notable feature of the durable goods is that the durable goods sector responds to monetary policy very sensitively. Nevertheless, most references for the analysis of optimal monetary policy have not investigated the role of durable goods.

Barsky et al. (2007) demonstrate that durable goods play a critical role in shaping dynamic responses of macroeconomic variables to monetary policy shocks in a New Keynesian model. They emphasize that the behavior of the model relies on the degree of price stickiness in a durable goods sector. In particular, they show that the inclusion of flexible-price durable goods dramatically changes the dynamics of the model in response to the monetary shock. Many literatures document heterogeneous price rigidity between nondurable goods and durable goods. Barsky et al. (2007) briefly mention about why the price of durable goods might be more flexible than that of nondurable goods is. The empirical evidence provided by Bils and Klenow (2004) and Klenow and Kryvtsov (2008) also points out that durable goods prices change more frequently than nondurable goods prices.

This paper seeks to investigate monetary policy rule, which is optimal within a family of interest rate feedback rules in a two-sector New Keynesian model with sticky-price nondurable goods and flexible-price durable goods. Aoki (2001) demonstrates that the optimal monetary policy is to stabilize sticky-price inflation, rather than aggregate price inflation in a model with a sticky-price sector and a flexible-price sector. However, the policy suggested by Aoki

(2001) is not a good policy because of its low feasibility. The reason is that the policy does not depend on any observable variables and would lead to the indeterminacy of equilibria. To overcome this problem, we construct an interest rate feedback rule relying only on observable variables, such as price inflation and output, and resulting in a unique equilibrium, following the approach suggested by Schmitt-Grohé and Uribe (2004a, 2007).[1] The optimal interest rate feedback rule maximizes welfare of the representative household. Therefore, we will show whether the feature of the optimal monetary policy suggested by Aoki (2001) is robust to the inclusion of durable goods even in the optimal interest rate feedback rule.

In addition, as mentioned by Aoki (2001), the execution of the optimal monetary policy to completely stabilize sticky-price inflation should require the information of exogenous shocks. In the real world, however, it is not possible for the central bank to directly observe them. The method proposed by Schmitt-Grohé and Uribe (2007) can be applied to the economy without the exact knowledge of the shocks. Therefore, in this paper, it is assumed that business cycles are driven by total factor productivity (TFP) shocks in nondurable goods sector and durable goods sector simultaneously.

Our findings about the optimal interest rate feedback rule in the two-sector New Keynesian model with sticky-price nondurable goods and flexible-price durable goods can be stated as follows: First of all, the optimal interest rate feedback rule yields the level of welfare close to that under the Ramsey optimal policy.[2] This provides the rationale for carrying out the interest rate feedback rule. Furthermore, responding to sticky-price inflation is better than responding to aggregate price inflation. This is because there does not exist a

1) Schmitt-Grohé and Uribe (2007) explain that such policy rule is a simple and implementable monetary policy rule.
2) The Ramsey optimal policy serves as a point of comparison for policy evaluation.

trade-off between stabilizing sticky nondurable goods price inflation and following the Ramsey optimal path of each sectoral output. However, there exists a trade-off between stabilizing aggregate price inflation and following the optimal path of each sectoral output. The policy which responds to aggregate price inflation results in the distortion of the relative price of durable goods. This result can contribute to the reinforcement of the finding from Aoki (2001).

The organization of the paper is as follows. Section 2 outlines a two-sector New Keynesian model incorporated with durable goods. Section 3 describes the parameter calibration and the solution method. Section 4 explains the measure of welfare. Section 5 investigates the results of the optimal monetary policy. Finally, Section 6 concludes.

Ⅱ. The Model

In this section, we extend the standard two-sector New Keynesian model of Barsky et al. (2007) by adding interest rate feedback rule. The economy consists of a representative household, a continua of firms in the two sectors that respectively produce differentiated nondurable and durable goods, perfectly competitive final goods firms in the two sectors, and a central bank.

1. Households

The household receives utility from the consumption of nondurable goods, durable services, and leisure, and maximizes the following utility program:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, D_t, N_t), \tag{1}$$

$$U(C_t, D_t, N_t) = (1-\alpha)\log C_t + \alpha \log D_t - \frac{\nu N_t^{1+\varphi}}{1+\varphi}, \tag{2}$$

where E_t denotes (conditional) expectations at any given period t. C_t denotes consumption of the final nondurable goods, D_t denotes services from the stock of the final durable goods at the end of period t, and α is the share of durable goods in the composite consumption. N_t denotes the labor supply, φ is the inverse elasticity of labor supply, and ν is a parameter that indexes the preference for hours worked of each agent.

Purchases of new durable goods X_t increases the household's durable stock according to

$$D_t = X_t + (1-\delta)D_{t-1} \tag{3}$$

where δ denotes the physical rate of depreciation.

In every period, the household faces the following constraints (in nominal terms):

$$P_{c,t}C_t + P_{x,t}X_t + B_t \le R_{t-1}B_{t-1} + W_t N_t - T_t + \Pi_t, \tag{4}$$

where the subscripts c and x denote variables that are specific to the non-durable and durable sectors, respectively. $P_{c,t}$ and $P_{x,t}$ are the nominal prices of the nondurable and durable goods, B_t is the stock of private one-period nominal bonds, R_t is the gross nominal interest rate, W_t is the nominal wage, T_t is the lump-sum government tax, and Π_t is the profits returned to the consumer through dividends. Labor is assumed to be perfectly mobile across sectors, implying that the nominal wage rate is common across sectors.

Let $\Lambda_t \equiv \dfrac{\lambda_t}{P_{c,t}}$ be defined as the multiplier on budget constraints

(4). The first-order conditions (in real terms) are as follows:

$$U_{c,t} = \lambda_t, \tag{5}$$

$$q_t U_{c,t} = U_{d,t} + \beta(1-\delta)E_t(q_{t+1}U_{c,t+1}), \tag{6}$$

$$\frac{-U_{n,t}}{U_{c,t}} = w_t, \tag{7}$$

$$1 = \beta\left(\frac{\lambda_{t+1}}{\lambda_t}\frac{R_t}{\pi_{c,t+1}}\right), \tag{8}$$

where $U_{c,t}$, $U_{d,t}$, and $-U_{n,t}$ are the marginal utilities of nondurables, durables, and leisure respectively, $q_t \equiv \frac{P_{x,t}}{P_{c,t}}$ is the relative price of durable goods, $\pi_{j,t} \equiv \frac{P_{j,t}}{P_{j,t-1}}$ is the gross inflation in each sector $(j = c, x)$, and $w_t \equiv \frac{W_t}{P_{c,t}}$ is the real wage.

In Equation (5), the household's marginal utility of nondurable consumption is equated to the shadow value of budget constraints (4). Equation (6) requires that the household to equate the marginal utility of nondurable consumption to the shadow value of durables. Equation (7) is the standard optimality condition for labor, which equates the marginal rate of substitution between leisure and consumption to the real wage. Finally, Equation (8) is the standard Euler equation.

2. Firms

We assume the existence of a continuum of monopolistically competitive firms, indexed by $s \in [0,1]$, which produce differentiated intermediate goods in each sector. A final good in each sector is produced by a perfectly competitive representative firm. The firm produces the final good by combining a continuum of intermediate goods.

1) Final Goods Firms

The final good in each sector $(j=c,x)$ is aggregated by the constant elasticity of substitution (CES) technology:

$$Y_{j,t} \equiv \left(\int_0^1 Y_{j,t}(s)^{\frac{\varepsilon_j - 1}{\varepsilon_j}} ds \right)^{\frac{\varepsilon_j}{\varepsilon_j - 1}}, \tag{9}$$

where $Y_{j,t}(s)$ is the quantity of intermediate goods s used as an input in each sector, and ε_j is the elasticity of substitution of intermediate goods in each sector.

A cost minimization problem for the final good producer in each sector implies that the demand for intermediate goods is given by

$$Y_{j,t}(s) = \left(\frac{P_{j,t}(s)}{P_{j,t}} \right)^{-\varepsilon_j} Y_{j,t}, \tag{10}$$

where $P_{j,t}(s)$ is the price of intermediate good s in each sector, and $P_{j,t}$ is the aggregate price level in each sector. Finally, the zero-profit condition implies that the sectoral price index is expressed as

$$P_{j,t} \equiv \left(\int_0^1 P_{j,t}(s)^{1-\varepsilon_j} ds \right)^{\frac{1}{1-\varepsilon_j}}. \tag{11}$$

2) Intermediate Goods Firms

Intermediate goods producers in each sector $(j=c,x)$ are monopolistically competitive. Each intermediate goods firm produces its differentiated goods using the following linear production function:

$$Y_{j,t}(s) = A_{j,t} N_{j,t}(s), \tag{12}$$

where $A_{j,t}$ is a sectoral total factor productivity in each sector at time t. We assume that each sectoral technology evolves exogenously according to the following process:

$$\log A_{j,t} = \rho_{A_j} \log A_{j,t-1} + \varepsilon_{A_j,t}, \tag{13}$$

where $\varepsilon_{A_j,t}$ represents an i.i.d. productivity shock with mean zero and variance $\sigma^2_{A_j}$. The nondurables TFP shock and the durable TFP shock are assumed to be uncorrelated with one another.

Each firm s has monopolistic power in the production of its own variety and therefore has leverage in setting the price. In so doing, it faces a quadratic cost of nominal price adjustment in terms of the final goods, $AC_{j,t}(s)$, following Rotemberg (1982):

$$AC_{j,t}(s) = \frac{\phi_j}{2}\left(\frac{P_{j,t}(s)}{P_{j,t-1}(s)} - 1\right)^2 Y_{j,t}, \tag{14}$$

where ϕ_j measures the degree of sectoral nominal price rigidity.

Each intermediate good firm maximizes expected discounted nominal profits:

$$E_0 \sum_{t=0}^{\infty} \wp_t [P_{j,t}(s) Y_{j,t}(s) - W_t N_{j,t}(s) - P_{j,t} AC_{j,t}(s)], \tag{15}$$

subject to Equation (10). Here, $\wp_t \equiv \beta^t \frac{\Lambda_t}{\Lambda_0} = \beta^t \frac{\lambda_t}{\lambda_0} \frac{P_{c,0}}{P_{c,t}}$ is the stochastic discount factor for nominal payoffs of the households.

The first-order condition in each sector is as follows:

$$\phi_j(\pi_{j,t} - 1)\pi_{j,t} = \phi_j E_t \frac{\wp_{t+1}}{\wp_t} \frac{P_{j,t+1}}{P_{j,t}} \left[(\pi_{j,t+1} - 1)\pi_{j,t+1} \frac{Y_{j,t+1}}{Y_{j,t}}\right] + (1 - \varepsilon_j) + \varepsilon_j mc_{j,t}, \tag{16}$$

where $mc_{j,t} \equiv \frac{W_t / P_{j,t}}{A_{j,t}}$ is the real marginal cost function.

3. Symmetric Equilibrium and Market Clearing

We assume a symmetric equilibrium to rule out potential multiple equilibria in which identical agents behave differently because of different initial conditions. In a symmetric equilibrium, each intermediate good firm is endowed with the same initial condition and makes identical decision so that $P_{j,t}(s) = P_{j,t}$, $Y_{j,t}(s) = Y_{j,t}$, and $N_{j,t}(s) = N_{j,t}$.

Equilibrium in the goods market of each sector requires that the production of the final good be allocated to total households' expenditure and to resource costs originating from the adjustment of prices:

$$Y_{c,t} = C_t + \frac{\phi_c}{2}(\pi_{c,t} - 1)^2 Y_{c,t}, \tag{17}$$

$$Y_{x,t} = X_t + \frac{\phi_x}{2}(\pi_{x,t} - 1)^2 Y_{x,t}. \tag{18}$$

The economy-wide total output Y_t is given by

$$Y_t = Y_{c,t} + q Y_{x,t}, \tag{19}$$

where q is the deterministic steady-state value of the relative price of durable goods.

Equilibrium in the bond and labor market requires, respectively

$$B_t = 0, \tag{20}$$

$$N_t = N_{c,t} + N_{x,t}. \tag{21}$$

4. Central Bank

The monetary authority conducts monetary policy using the short-term nominal interest rate as the policy instrument. The gross nominal interest rate R_t follows the following Taylor-type rule:

$$\log\left(\frac{R_t}{R}\right) = \rho_\pi \log\left(\frac{\pi_t}{\pi}\right), \tag{22}$$

with $\rho_\pi \in (1,4]$, and where π_t is a composite inflation index. R and π correspond to deterministic steady-state values.

We define the composite inflation index π_t as

$$\pi_t = \pi_{c,t}^{1-\phi} \pi_{x,t}^{\phi}, \tag{23}$$

where ϕ is the weight of durables in the composite inflation index in the interest rate feedback rule. Simply put, by setting $\phi = 0$, the monetary authority uses only the sticky nondurable price inflation as its composite inflation index; by setting $\phi = 0.20$, it uses aggregate inflation as its index.

As suggested by Schmitt-Grohéand Uribe (2007), we construct monetary policy in terms of a simple and implementable rule, whereby the central bank sets the short-run nominal interest rate in response to observable variables only.

Ⅲ. Calibration and Solution Method

The models are calibrated to a quarterly frequency. Table 1 provides a summary of the key parameters. Since we choose an annual real rate of return of 4 percent and the steady-state real rate of interest is pinned down by the household's discount factor, $\beta = 0.99$. The share of durable consumption in the aggregate spending index αis set that the steady-state share of durable spending in total private spending is about 20 percent. That is, $\alpha = 0.3416$. We set an annual depreciation rate for durable goods of 4 percent, hence $\delta = 0.01$. The inverse elasticity of labor supply is set $\varphi = 1$. Labor preference parameters vis set in such a way that each individual agent chooses to work 1(= N). Finally, the elasticities of substitution among varieties, ε_c and ε_x, are set equal to 6, implying steady-states mark-up of 20 percent.

【Table 1】 Baseline Quarterly Parameters

Parameter	Description	Value
β	Discount factor for household	0.99
α	Share of durable expenditure	0.3416
δ	Depreciation rate of durable goods	0.01
φ	Inverse elasticity of labor supply	1.00
N	Steady state of hours worked that household chooses	1.00
ε_c	Elasticity of substitution among nondurable varieties	6.00
ε_x	Elasticity of substitution among durable varieties	6.00
θ_c	Calvo parameter for nondurable goods price	0.75
θ_x	Calvo parameter for durable goods price	0
ρ_{A_c}	Persistence parameter of nondurable-sector TFP shock	0.95
ρ_{A_x}	Persistence parameter of durable-sector TFP shock	0.997
σ_{A_c}	Volatility(standard deviation) of nondurable-sector TFP shock	0.01
σ_{A_x}	Volatility(standard deviation) of durable-sector TFP shock	0.0193

In order to parameterize the degree of price stickiness, by log-linearizing the first-order condition of the intermediate good firms in each sector $j=c,\ x$ around a zero-inflation steady state, we can obtain an elasticity of inflation to real marginal cost that takes the form $\frac{\varepsilon_j - 1}{\phi_j}$. 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 $\frac{(1-\theta_j)(1-\beta\theta_j)}{\theta_j}$, where θ_j is the probability of not resetting the price of each good. Thus, matching those two coefficients yields $\phi_j = \frac{\theta_j(\varepsilon_j - 1)}{(1-\theta_j)(1-\beta\theta_j)}$. We set the degrees of nominal rigidities in nondurables price (ϕ_c) to generate a frequency of price adjustment of about four quarters. Thus, we parameterize $\theta_c = 0.75$. On the other hand, we set the degrees of nominal rigidities in durables price (ϕ_x) to full flexibility, i.e. $\theta_x = 0$.

As estimated by Iacoviello and Neri (2010), the persistence parameters of nondurable-sector TFP shock (ρ_{A_c}) and durable-sector TFP shock (ρ_{A_x}) are set equal to 0.95 and 0.997 respectively. The standard deviations of these shocks (ρ_{A_c} and ρ_{A_x}) are equal to 0.01 and 0.0193 respectively.

We solve the model by computing a second-order approximation of the policy functions around the non-stochastic steady state. We follow the approach pioneered by Schmitt-Grohé and Uribe (2004a, 2007).

Ⅵ. Welfare Measure

We conduct policy evaluation by computing the welfare cost under a particular monetary policy in contrast to the time-invariant stochastic equilibrium allocation associated with the Ramsey policy. We define the welfare associated with the time-invariant stochastic allocation implied by the Ramsey policy conditional on the state of the economy in period 0 as

$$V_0^r = E_0 \sum_{t=0}^{\infty} \beta^t U(C_t^r, D_t^r, N_t^r). \tag{24}$$

In the same manner, we define the conditional welfare associated with alternative policy a as

$$V_0^a = E_0 \sum_{t=0}^{\infty} \beta^t U(C_t^a, D_t^a, N_t^a). \tag{25}$$

We assume that all the state variables at time 0 are to equal their respective Ramsey steady-state values. Since the non-stochastic steady state values are equal across all policy rules considered in our analysis, computing expected welfare conditional on the initial state being equal to the non-stochastic steady state ensures that the economy starts from same initial point under all policies.

Let Ω denote the welfare cost associated with policy regime a instead of the Ramsey policy r. We measure Ω as the fraction of the Ramsey's consumption process that a household is willing to give up to feel indifferent between being under regime a and under the Ramsey policy r:

$$V_0^a = E_0 \sum_{t=0}^{\infty} \beta^t U((1-\Omega) C_t^r, D_t^r, N_t^r). \tag{26}$$

Under our specification of utility, we can solve for Ω and obtain the welfare cost:

$$\begin{aligned} Welfare\ cost &= \Omega \times 100 \\ &= \left[1 - \exp\left(\frac{(1-\beta)(V_0^a - V_0^r)}{1-\alpha}\right)\right] \times 100. \end{aligned} \tag{27}$$

Thus, a positive figure indicates that a higher level of welfare is achieved under the Ramsey policy than under the alternative policy.

Ⅴ. Results

1. Sticky-Price Inflation VS Aggregate Price Inflation

Now, we characterize the optimal interest rate feedback rule for the economy described by the model above in terms of welfare cost. The main objective of a central bank is to maximize welfare level of the representative household. We investigate how the central bank could achieve this goal in the interest rate rule given TFP shocks in nondurable goods sector and durable goods sector simultaneously.

【Table 2】 Optimal Interest Rate Feedback Rule and Welfare Cost[3)]

	ρ_π	ϕ	Welfare cost ($\Omega \times 100$)
ROP			0
OIRFRS	4.0	0	0.000942847
OIRFRA	2.4	0.2	0.009467067

Note: ROP ≡ Ramsey optimal policy, OIRFRS ≡ optimal interest rate feedback rule responding to sticky nondurable goods price inflation, and OIRFRA ≡ optimal interest rate feedback rule responding to aggregate price inflation.

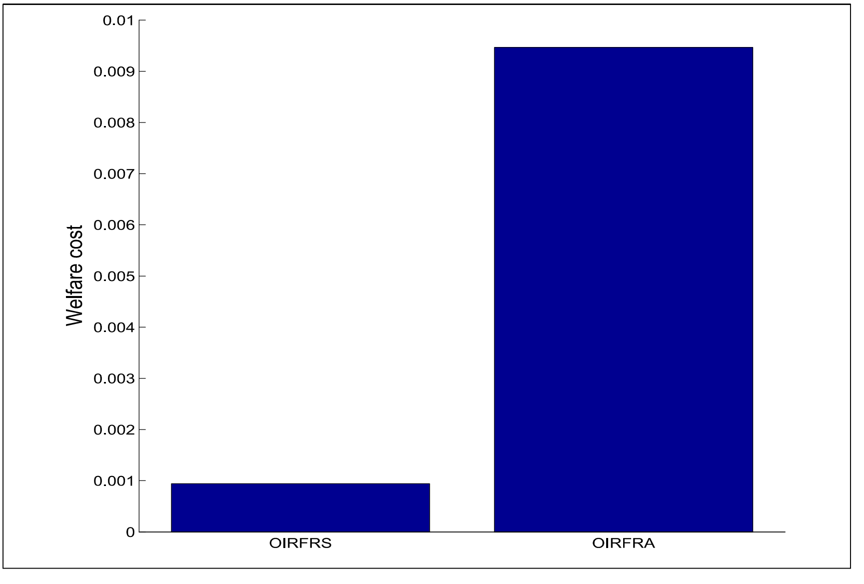
Table 2 presents the policy evaluation results for the economy with sticky-price nondurable goods and flexible-price durable goods. Optimal interest rate feedback rule minimizing welfare cost is $\rho_\pi = 4.0$ and $\phi = 0$, and the welfare cost is 0.000942847. This implies that by responding to sticky nondurables price inflation only, the interest rate rule can attain the welfare very close to that under the

3) The same results are obtained even though we introduce price rigidity in a Calvo fashion.

Ramsey optimal policy.

On the other hand, if the central bank responded to aggregate price inflation ($\phi = 0.2$), the optimal coefficient of interest rate feedback rule would be $\rho_{\pi} = 2.4$, and welfare cost is 0.009467067. As also shown in Figure 1, the welfare cost is about 10 times larger than that under the interest rate feedback rule responding to sticky-price inflation only. This provides the reason for implementing the interest rate feedback rule responding to sticky-price inflation, rather than aggregate price inflation.

【Figure 1】 Welfare Costs given Two Shocks: Nondurable-Sector and Durable-Sector TFP Shocks



Note: OIRFRS≡optimal interest rate feedback rule responding to sticky nondurable goods price inflation and OIRFRA≡optimal interest rate feedback rule responding to aggregate price inflation.

2. Why Should the Central Bank Respond to Sticky-Price Inflation?

Then, we show why the central bank should respond to sticky-price inflation only in the model with sticky-price nondurable goods and flexible-price durable goods. From now on, it is assumed that the central bank can observe each sectoral TFP shock. We analyze impulse responses to each TFP shock.

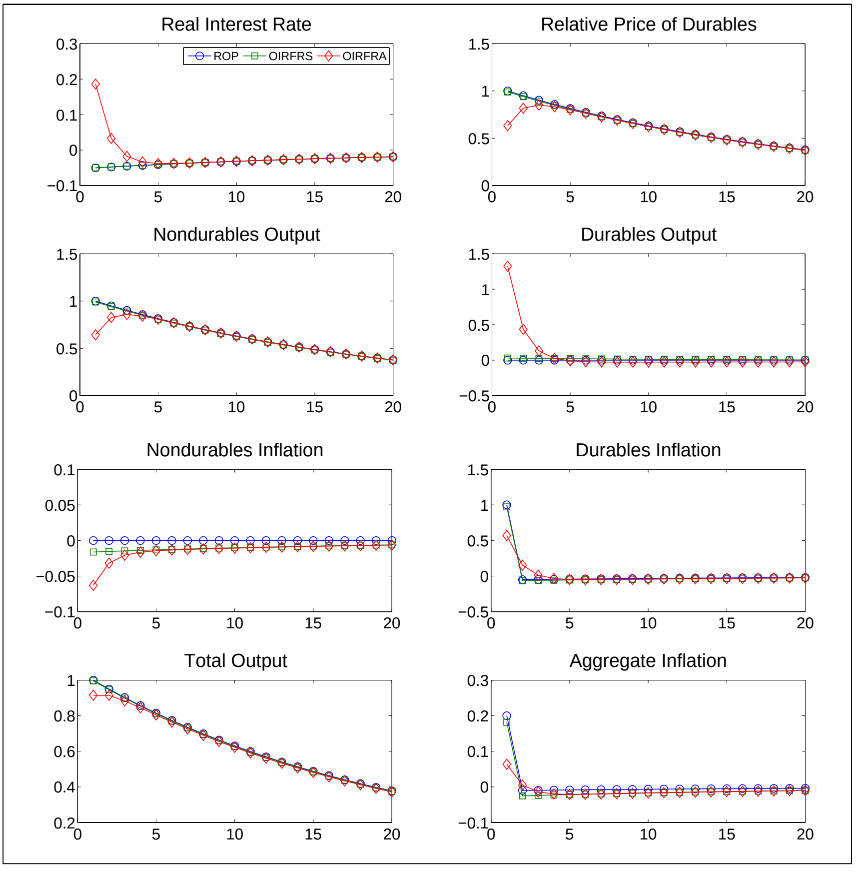
1) TFP Shock in Nondurable Goods Sector

Figure 2 describes the IRFs for the key endogenous variables to a positive TFP shock in a nondurable goods sector for the two-sector model with sticky-price nondurable goods and flexible-price durable goods. The figure presents the IRFs associated with three monetary policy rules: Ramsey optimal policy (ROP), optimal interest rate feedback rule responding to sticky-price inflation (OIRFRS), and optimal interest rate feedback rule responding to aggregate price inflation (OIRFRA).

The positive shock in the nondurable goods sector results in an increase in nondurable output. Thus, the Ramsey optimal policy features a fall in the real interest rate in order to stabilize nondurables price inflation under downward pressure. The increase in the consumption of nondurable goods would raise the consumption of durable goods due to wealth effect. However, the wealth effect is completely offset by an increase in the relative price of durable goods and the expectation of a capital loss on durable goods ($\Delta \hat{q}_{t+1} < 0$). Therefore, durable goods output is not affected by the shock.

The optimal interest rate feedback rule, which responds to sticky nondurables price inflation, can replicate the performance of the Ramsey optimal policy. By responding to nondurables price inflation under downward pressure, the optimal interest rate feedback rule is able to decrease the real interest rate like the Ramsey optimal policy. Consequently, the central bank achieves both the stabilization of sticky price inflation in nondurable goods sector and the replication

【Figure 2】 Impulse Response Functions for Nondurable-Sector TFP Shock



Note: The horizontal axes take the quarters after the shock and the vertical axes measure percentage deviations from the steady state (Responses of real interest rate and inflations are plotted as percentage point deviations from steady state). The above figures depict the responses of the economy to a positive TFP shock for nondurable goods sector.

of the Ramsey optimal path of each sectoral output. On the other hand, if the central bank carried out the optimal interest rate feedback rule responding to aggregate price inflation under upward pressure, the real interest rate would increase. Then, stabilizing aggregate price inflation results in the distortion of the relative price of durable goods. The distortion induces the expectation of a positive capital gain on durable goods ($\Delta \hat{q}_{t+1} > 0$). As a result, this amplifies output in durable goods sector. Nondurable goods output increases less than that under the Ramsey optimal policy. This implies that there exists a trade-off between stabilizing aggregate price inflation and following the Ramsey optimal path of each sectoral output. Therefore, the central bank should respond to sticky nondurable goods price inflation, rather than aggregate price inflation given the TFP shock in the nondurable goods sector.

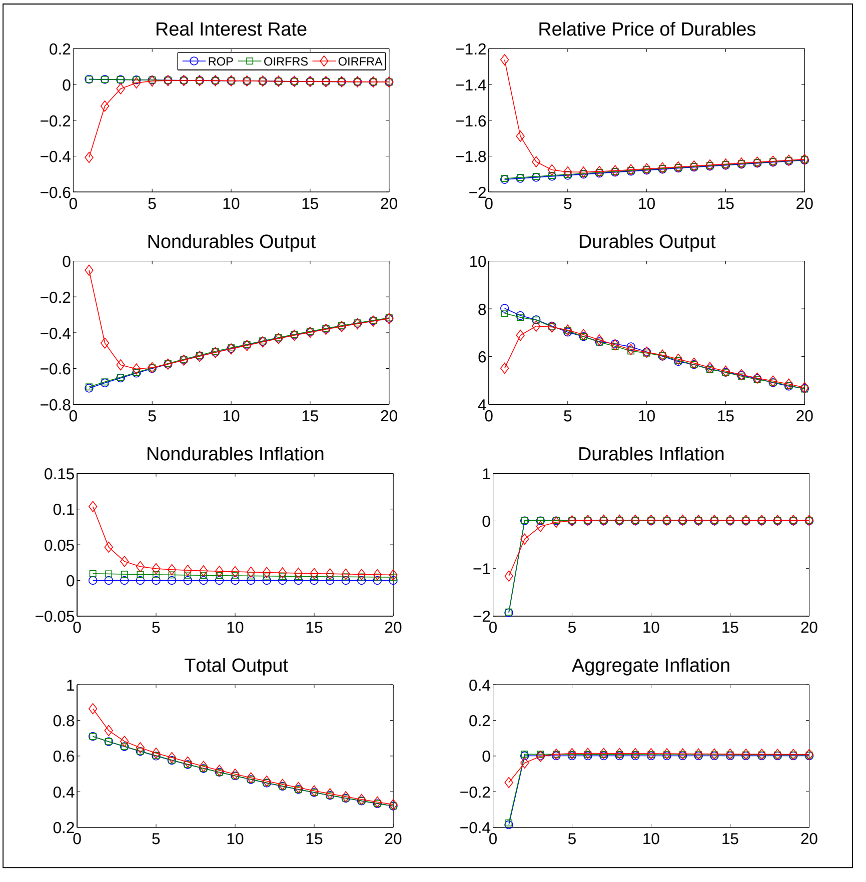
2) TFP Shock in Durable Goods Sector

Figure 3 plots the IRFs for the key endogenous variables to a positive TFP shock in a durable goods sector for the two-sector model with sticky priced nondurable goods and flexible priced durable goods. When business cycles are driven by the TFP shock in durable goods sector, the feature of the optimal interest rate feedback rule mentioned above is maintained.

The shock in the durable goods sector leads to an increase in durable goods output. Consequently, the relative price of durable goods falls immediately because the price of durable goods is flexible. The consumption of durable goods rises considerably due to a decrease in the relative price of durable goods and the expectation of a positive capital gain on durable goods ($\Delta \hat{q}_{t+1} > 0$). As a result, the output of nondurables goods decreases. Thus, the Ramsey optimal policy requires an increase in the real interest rate in order to stabilize nondurables price inflation under upward pressure.

The optimal interest rate feedback rule, which responds to sticky nondurables price inflation, is able to approximate the Ramsey optimal policy. Responding to nondurables price inflation under upward pressure raises the real interest rate. By doing so, the central bank accomplishes the goals which are the stabilization of sticky nondurable goods price inflation and the replication of the Ramsey optimal path of each sectoral output. In contrast, responding to aggregate price inflation under downward pressure induces a fall in

【Figure 3】 Impulse Response Functions for Durable-Sector TFP Shock



Note: The horizontal axes take the quarters after the shock and the vertical axes measure percentage deviations from the steady state (Responses of real interest rate and inflations are plotted as percentage point deviations from steady state). The above figures depict the responses of the economy to a positive TFP shock for durable goods sector.

the real interest rate would decrease. Then, stabilizing aggregate price inflation causes the distortion of the relative price of durable goods. A capital loss on durable goods ($\Delta \hat{q}_{t+1} < 0$) is expected. Consequently, the expectation shrinks an increase in durable goods output. Nondurable goods output decreases less than that under the Ramsey optimal policy. Hence, the central bank cannot achieve the goals at the same time, which are to stabilize aggregate price inflation and to replicate the Ramsey optimal path of each sectoral output. This shows that the central bank should also respond to sticky nondurable goods price inflation, rather than aggregate price inflation given the TFP shock in the durable goods sector.

Ⅵ. Conclusion

This paper investigated that optimal interest rate feedback rule in an economy with heterogeneous price rigidity and durable goods. To be specific, our analysis is based on the standard two-sector New Keynesian model of Barsky et al. (2007) with sticky-price nondurable goods and flexible-price durable goods. Many literatures point out that the price of durable goods is more flexible than that of nondurable goods. Aoki (2001) demonstrated that the optimal monetary policy is to stabilize sticky-price inflation, rather than aggregate price inflation when there are a sticky-price sector and a flexible-price sector. However, the policy proposed by Aoki (2001) is an unfeasible policy because it relies on unobservable variables. To resolve this problem, we employed the method suggested by Schmitt-Grohéand Uribe (2007) to propose the optimal interest rate feedback rule which consists of observable variables only.

We can conclude with two remarks. First, the optimal interest rate feedback rule can attain the welfare close to that under the Ramsey optimal policy even in the model with heterogeneous price rigidity and durable goods. Second, the optimal rule features responding to sticky nondurable goods price inflation only, rather than aggregate price inflation. It is legitimate to say that the result supports the finding from Aoki (2001). By responding to sticky nondurable goods price inflation, a central bank can achieve the two goals simultaneously, which are to stabilize sticky nondurable goods price inflation and to follow the Ramsey optimal path of each sectoral output. However, responding to aggregate price inflation results in larger welfare loss due to the distortion of the relative price of durable goods. Therefore, the central banks should carry out the interest rate feedback rule, which responds to sticky nondurable goods price inflation only when the economy has durable goods and heterogeneous price stickiness.

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Appendix

Ramsey Optimal Monetary Policy

For given stochastic processes $\{A_{c,t}, A_{x,t}\}$, the Ramsey planner plans for the control variables $\{\lambda_t, C_t, D_t, X_t, b_t, N_t, w_t, q_t, R_t, \pi_{c,t}, \pi_{x,t}, N_{c,t}, N_{x,t}, mc_{c,t}, mc_{x,t}, Y_{c,t}, Y_{x,t}\}_{t=0}^{\infty}$, and for the costate variables $\{\mu_{k,t}\}_{t=0}^{\infty}$:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left\{ (1-\alpha)\log C_t + \alpha \log D_t - \frac{\nu N_t^{1+\varphi}}{1+\varphi} \right\}$$

subject to

1. Relative price of durable goods

$$q_t = \frac{\pi_{x,t}}{\pi_{c,t}} q_{t-1},$$

2. Household's nondurable goods consumption

$$(1-\alpha) C_t^{-1} = \lambda_t,$$

3. Household's durable goods consumption

$$\alpha D_t^{-1} = \lambda_t q_t - \beta(1-\delta) E_t(\lambda_{t+1} q_{t+1}),$$

4. Household's law of motion for durable goods

$$D_t = X_t + (1-\delta) D_{t-1},$$

5. Household's labor supply decision

$$\nu N_t^{\varphi} = \lambda_t w_t,$$

6. Household's Euler equation

$$1 = \beta E_t\left(\frac{\lambda_{t+1}}{\lambda_t}\frac{R_t}{\pi_{c,t+1}}\right),$$

7. New Keynesian Phillips curve for nondurable goods

$$\phi_c(\pi_{c,t}-1)\pi_{c,t} = \phi_j E_t \frac{\lambda_{t+1}}{\lambda_t}\left[(\pi_{c,t+1}-1)\pi_{c,t+1}\frac{Y_{c,t+1}}{Y_{c,t}}\right] + (1-\varepsilon_c) + \varepsilon_c mc_{c,t},$$

8. Marginal costs for nondurable goods

$$mc_{c,t} = \frac{w_t}{A_{c,t}},$$

9. New Keynesian Phillips curve for durable goods

$$\phi_x(\pi_{x,t}-1)\pi_{x,t} = \phi_x E_t \frac{\lambda_{t+1}}{\lambda_t}\frac{q_{t+1}}{q_t}\left[(\pi_{x,t+1}-1)\pi_{x,t+1}\frac{Y_{x,t+1}}{Y_{x,t}}\right] + (1-\varepsilon_x) + \varepsilon_x mc_{x,t},$$

10. Marginal costs for durable goods

$$mc_{x,t} = \frac{w_t/q_t}{A_{x,t}},$$

11. Production function for nondurable goods

$$Y_{c,t} = A_{c,t}N_{c,t},$$

12. Production function for durable goods

$$Y_{x,t} = A_{x,t} N_{x,t},$$

13. Nondurable good markets clearing

$$Y_{c,t} = C_t + \frac{\phi_c}{2}(\pi_{c,t} - 1)^2 Y_{c,t},$$

14. Durable good markets clearing

$$Y_{x,t} = X_t + \frac{\phi_x}{2}(\pi_{x,t} - 1)^2 Y_{x,t},$$

15. Labor markets clearing

$$N_t = N_{c,t} + N_{x,t},$$

16. TFP shock in nondurable goods sector

$$\log A_{c,t} = \rho_{A_c} \log A_{c,t-1} + \varepsilon_{A_c,t},$$

17. TFP shock in durable goods sector

$$\log A_{x,t} = \rho_{A_x} \log A_{x,t-1} + \varepsilon_{A_x,t}.$$

이질적 가격 경직성, 내구재, 그리고 최적 통화 정책

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논문초록

이 논문은 이질적 가격 경직성과 내구재가 존재하는 경제에서의 최적 이자율 정책에 대해 연구한다. 많은 문헌들이 내구재의 가격이 비내구재의 가격보다 더 유동적이라고 명시하고 있다. 우리의 연구는 가격 경직적인 비내구재와 가격 유동적인 내구재가 존재하는 뉴케인지안 모형을 기반으로 한다. 이 모형에서의 최적 이자율 정책에 관한 우리의 발견은 다음과 같다: 첫째, 이 모형에서도 최적 이자율 정책으로 램지 최적 정책 하에서의 후생과 근사한 수준의 후생을 얻을 수 있다. 또한, 최적 이자율 정책의 주된 특징은 종합 인플레이션이 아니라 경직적인 가격의 인플레이션에만 반응해야 한다는 것이다. 이 이유는 가격 경직적인 비내구재의 인플레이션을 안정시키는 것과 각 섹터 별 생산량의 램지 최적 변동을 따르게 하는 것 사이에 상반관계가 없기 때문이다. 하지만, 종합 인플레이션에 반응하는 정책은 내구재의 상대가격 왜곡을 일으켜 큰 후생 손실을 야기한다.

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