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Monetary Policy Effects in Developing Countries with Minimum Wages

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1. Introduction

Using a Dynamic General Equilibrium (DGE) model, this study examines the effects of monetary policy in economies where minimum wages are bound. Some researchers have already examined monetary-policy effects based on DGE models. However, the assumptions of the models have not reflected the situation in developing countries in one important way, that being the effects of a binding minimum wage.

To have effective monetary policy in an economic model, we often assume some kind of price rigidity. In previous research the negotiation of wages between a union and a company is typically assumed as an explanation of such rigidity. A wage level is negotiated, and once agreed on, that level is fixed for a certain period of time. After that period, negotiations are undertaken again to set a new wage level. The wage level under this system is not completely flexible, and while reflecting, for example, the U.S. wage determination process, this system does not depict the wage determining process in developing countries. In these countries workers are often paid at the minimum-wage level, most often because the supply of labor in these countries is much larger than the labor demand. As a result the market-level wage goes down. Even if a country has a system of minimum wages, the market-level wage adjusts lower than the minimum-wage level. Thus in a developing country the minimum wage binds, and it is the level that is paid to workers.

Given this situation, in order to understand the effects of monetary policy in developing countries, we need to construct a new model with a binding minimum wage. In this paper we construct such a model and compare the monetary-policy effect in the model to the effect in a model with union-negotiation assumptions. Through this comparison, this study will show how monetary policy affects economies with binding minimum wages.

2.1. The Union-Negotiation Model

Based on Benassy (1995), the following model is used as a union-negotiation model. C, M, P, N, I, K and Z represent consumption, money, price level, labor, investment, capital, and technology, respectively. $\overline{N}$ is the total amount of time an agent has. Thus $\overline{N} - N$ represents leisure time.

The utility of the agent over time is expressed as

$$U = E_0 \sum_{t=0}^{\infty} \left[\log C_t + \theta \log \frac{M_t}{P_t} + \gamma \log(\overline{N} - N_t) \right]. \tag{1}$$

One of the features of the utility function is that it includes M, money. Budget constraints include M corresponding to money in the utility function.

$$C_t + \frac{M_t}{P_t} + I_t = \frac{W_t}{P_t} N_t + r_t K_{t+1} + \frac{\mu_t M_{t-1}}{P_t} \tag{2}$$

To express money growth, we use the usual assumption:

$$M_t = \mu_t M_{t-1}. \tag{3}$$

Later we will assume a probability process for M. Therefore this expression will be replaced by

$$\log M_t = \log M_{t-1} + \varepsilon_{m,t} \quad \text{where} \quad \varepsilon_{m,t} \sim N(0, \sigma_m^2). \tag{4}$$

The production side is written as

$$Y_t = Z_t K_t^{\alpha} N_t^{1-\alpha} \tag{5}$$

$$K_{t+1} = I_t \tag{6}$$

$$\log Z_t = \rho_z \log Z_{t-1} + \varepsilon_{z,t} \quad \text{where} \quad \varepsilon_{z,t} \sim N(0, \sigma_z^2) \tag{7}$$

The market clearing condition is

$$Y_t = C_t + I_t. \tag{8}$$

2.2. Necessary Conditions under Wage Stickiness

In this union-negotiation model we assume the typical wage stickiness presented in the literature. As the period of the previously negotiated wage level is closing, workers negotiate with the firm for a new wage level. Forecasting the equilibrium amount of labor in the new period, both sides seek an agreement on the wage level in the new period. Once they have come to an agreement, the firm can hire as much labor as it wants at the new wage level. At the end of the period, the wage level is renegotiated for the next period.

Having adopted this wage stickiness, we need a labor demand equation and a labor supply equation. We derive the first order conditions for the consumer and the firm separately.

The consumer's Lagrangean and FOCs can be written as

$$L = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \left[\log C_t + \theta \log \frac{M_t}{P_t} + \gamma \log(\overline{N} - N_t) \right] + \lambda_t \left[\frac{W_t}{P_t} N_t + r_t K_t + \frac{\mu_t M_{t-1}}{P_t} - C_t - \frac{M_t}{P_t} - K_{t+1} \right] \right\} \tag{9}$$

$$\frac{1}{C_t} = \lambda_t \tag{10}$$

$$\frac{\gamma}{\overline{N} - N_t} = \frac{W_t}{P_t} \lambda_t \tag{11}$$

$$\lambda_t = \beta E_t (\lambda_{t+1} r_{t+1}) \tag{12}$$

$$\lambda_t = \frac{\theta P_t}{M_t} + \beta E_t \left[\lambda_{t+1} \frac{\mu_{t+1} P_t}{P_{t+1}} \right] . \tag{13}$$

The producer's profit function and FOCs are

$$\pi_t = Z_t K_t^{\alpha} N_t^{1-\alpha} - \frac{W_t}{P_t} N_t - r_t K_t \tag{14}$$

$$r_t = \alpha Z_t K_t^{\alpha-1} N_t^{1-\alpha} \tag{15}$$

$$\frac{W_t}{P_t} = (1-\alpha) Z_t K_t^{\alpha} N_t^{-\alpha} . \tag{16}$$

(11) and (16) are the labor supply equation and the labor demand equation, respectively.

Other original conditions are

$$M_t = \mu_t M_{t-1} . \tag{17}$$

$$Y_t = Z_t K_t^{\alpha} N_t^{1-\alpha} \tag{18}$$

$$K_{t+1} = I_t \tag{19}$$

$$\log Z_t = \rho_z \log Z_{t-1} + \varepsilon_{z,t} \quad \text{where} \quad \varepsilon_{z,t} \sim N(0, \sigma_z^2) \tag{20}$$

$$Y_t = C_t + I_t\,. \tag{21}$$

These are the usual necessary conditions. Since we are assuming wage stickiness, as mentioned above, some equations can be replaced. But before doing this, we will simplify some equations.

From equations (10), (12), (15), (18) and (21), we can derive

$$\frac{I_t}{C_t} = \alpha\beta + \alpha\beta \mathrm{E}_t\left(\frac{I_{t+1}}{C_{t+1}}\right).$$

Eliminating the explosion of variables and combining with (21), we have

$$C_t = (1-\alpha\beta)Y_t \tag{22}$$

$$I_t = \alpha\beta Y_t\ . \tag{23}$$

We can now solve a system of equations, composed of the labor demand equation (16) and labor supply equation (11), for the expected equilibrium labor amount. By using (10), (18), and (22) we can simplify the result as

$$N \equiv \frac{(1-\alpha)\overline{N}}{\gamma(1-\alpha\beta)+(1-\alpha)}\ . \tag{24}$$

The solution includes parameters only. Therefore the expected amount of labor is a constant. Substituting (24) into (16) and taking the logs of both sides, we can show that

$$w_t = \log(1-\alpha) + m_t - n - v \tag{25}$$

$$\text{where}\quad n = \log N,\quad v = \log\left[\frac{\theta(1-\alpha\beta)}{1-\beta}\right]\ .$$

In our assumption the wage level is determined at the end of the previous period. Therefore equation (25) is replaced with

$$w_t = E_{t-1}(m_t) + \log(1-\alpha) - n - v\,. \tag{26}$$

Now we have all the necessary conditions for solving the problem. They are (10), (12), (13), (15), (16), (17)~(21), and (26). Notice that labor supply equation (11) is not included. (11) has been embodied in (24).

2.3. Log-linearization

In this section we log-linearize the set of necessary conditions. The variables with a tilde are defined as

$\tilde{x}_t \equiv \log X_t - \log X$ where X is the steady state value of X_t .

The results of the log-linearization of the conditions are as follows:

$$\tilde{r}_t = \tilde{z}_t + (\alpha - 1)\tilde{k}_t + (1-\alpha)\tilde{n}_t$$
$$\tilde{w}_t - \tilde{p}_t = \tilde{z}_t + \alpha\tilde{k}_t - \alpha\tilde{n}_t$$
$$-E_t(\tilde{c}_{t+1}) + E_t(\tilde{r}_{t+1}) = -\tilde{c}_t$$
$$\frac{\frac{\beta}{C}\left[-E_t(\tilde{c}_{t+1}) + E_t(\tilde{m}_{t+1}) - E_t(\tilde{p}_{t+1})\right]}{\frac{P}{M} + \frac{\beta}{C}} = q\tilde{m}_t - q\tilde{p}_t - \tilde{c}_t$$

where $q \equiv \left(\frac{\theta P}{M} + \frac{\beta}{C}\right) \Big/ \left(\frac{P}{M} + \frac{\beta}{C}\right)$

$$\tilde{y}_t = \frac{C}{C+I}\tilde{c}_t + \frac{I}{C+I}\tilde{i}_t$$
$$\tilde{m}_t = \tilde{m}_{t-1} + \varepsilon_{m,t}$$
$$\tilde{z}_t = \rho_z \tilde{z}_{t-1} + \varepsilon_{z,t}$$

$$\tilde{w}_t = \tilde{m}_{t-1}$$
$$\tilde{k}_{t+1} = \tilde{i}_t$$
$$\tilde{y}_t = \tilde{z}_t + \alpha\tilde{k}_t + (1-\alpha)\tilde{n}_t$$

2.4. Steady State

From the set of necessary conditions, (10), (12), (13), (15), (16), (17)~(21), and (26), we can derive the steady state values of the variables.

$$N^* = \frac{(1-\alpha)\overline{N}}{\gamma(1-\alpha\beta)+(1-\alpha)}$$

$$K = \left(\frac{1}{\alpha\beta}\right)^{\frac{1}{\alpha-1}} N^*$$

$$I = \left(\frac{1}{\alpha\beta}\right)^{\frac{1}{\alpha-1}} N^*$$

$$Y = \left(\frac{1}{\alpha\beta}\right)^{\frac{\alpha}{\alpha-1}} N^*$$

$$C = \left[\left(\frac{1}{\alpha\beta}\right)^{\frac{\alpha}{\alpha-1}} - \left(\frac{1}{\alpha\beta}\right)^{\frac{1}{\alpha-1}}\right] N^*$$

$$P = \frac{1-\beta}{\theta}\frac{1}{C} \qquad \text{assuming} \quad \mathrm{M}=1$$

$$W = \frac{(1-\alpha)}{NV} \qquad \text{where } V = \frac{\theta(1-\alpha\beta)}{1-\beta}$$

$$r = \alpha\frac{Y}{K}$$

3. The Minimum-Wage Model

Basically the model is the same as the union-negotiation model. But the following points are different. There is no negotiation through unions. The wage level is set at the market level determined by labor demand and supply; or if the market-level wage is lower than the minimum wage, the minimum wage is paid. In this paper the latter case is assumed, that the minimum wage binds.

$W = \overline{W}$ where $\overline{W}$ is the minimum wage. (27)

Regarding log-linearization, the equations are almost the same as those in the union-negotiation model. In the set of log-linearized equations in the union-negotiation model, we only need to replace (28) with (29).

$$\tilde{w}_t = \tilde{m}_{t-1} \tag{28}$$

$$\tilde{w}_t = 0 \tag{29}$$

We can now log-linearize. In the union-negotiation model, (11) is the labor supply function. In the minimum wage model, (27) is that function. Since (16) is the labor demand function, by combining (16) and (27), we can solve for labor in the minimum-wage model. Using the combination of (22) and (18) and the combination of (10), (13), and (17) in order to eliminate Z and K in (16), we have the steady state level N in the minimum wage model.

$$N^{**} = \frac{(1-\alpha)(1-\beta)}{\overline{W}\theta(1-\alpha\beta)}$$

The other steady state variables can be obtained by replacing N* in the steady state of the union negotiation model with N**.

$$K = \left(\frac{1}{\alpha\beta}\right)^{\frac{1}{\alpha-1}} N^{**}$$

$$I = \left(\frac{1}{\alpha\beta}\right)^{\frac{1}{\alpha-1}} N^{**}$$

$$Y = \left(\frac{1}{\alpha\beta}\right)^{\frac{\alpha}{\alpha-1}} N^{**}$$

$$C = \left[\left(\frac{1}{\alpha\beta}\right)^{\frac{\alpha}{\alpha-1}} - \left(\frac{1}{\alpha\beta}\right)^{\frac{1}{\alpha-1}}\right] N^{**}$$

$$P = \frac{1-\beta}{\theta}\frac{1}{C} \qquad \text{assuming} \quad \mathrm{M} = 1$$

$$W = \overline{W}$$

$$r = \alpha\frac{Y}{K}$$

4. Simulation Result

By applying a Blanchard-Kahn (1980) form to the log-linearized necessary conditions, we can obtain equations which can be used to simulate the model. The values of the parameters come from King and Rebelo (2000).

Table 1. Parameters

α	β	γ	$\overline{N}$	M	σ_z^2
0.58	0.988	3.48	1	1	1

Fixing these parameters changes the values of σ^2_m and θ. The results of the simulation are shown in Table 2, Figure 1 and Figure 2. Note that all the lowercase variables represent growth rates, not level amounts.

Table 2. Correlations of m and Other Variables

		corr(m,y)	corr(m, c)	corr(m,i)	corr(m,p)	corr(m,w-p)
$\sigma_M^2 = 1$	U	0.58	0.58	0.58	0.31	-0.31
$\theta = 0.1$	M	0.09	0.09	0.09	0.04	-0.04
$\sigma_M^2 =0.5$	U	0.45	0.45	0.45	0.22	-0.22
$\theta = 0.1$	M	0.06	0.06	0.06	0.03	-0.03
$\sigma_M^2 =0.1$	U	0.22	0.22	0.22	0.10	-0.10
$\theta = 0.1$	M	0.03	0.03	0.03	0.01	-0.01
$\sigma_M^2 = 1$	U	0.49	0.49	0.49	0.37	-0.37
$\theta = 0.2$	M	0.13	0.13	0.13	0.09	-0.09
$\sigma_M^2 = 1$	U	0.42	0.42	0.42	0.45	-0.45
$\theta = 0.5$	M	0.23	0.23	0.23	0.25	-0.25

* U and M indicate the union-negotiation model and the minimum-wage model,respectively.

Table 2 shows that the smaller σ_M^2 is, the less effective monetary policy is. But this is not necessarily so. In correlation, the magnitude of monetary policy would not be so important. Even if the policy's magnitude were small, if the direction of change in an economic variable were the same as the direction of change in the policy variable, the correlation between these two variables could be larger. The situation of a smaller σ_M^2 correlating with a less effective monetary policy would mean that the balance of monetary policy and productivity shock is important. If the productivity shock were large, then monetary policy would have to be large to be effective.

Moreover, from Table 2 we can say that the correlation between monetary policy and other variables is much larger in the union-negotiation model than in the minimum-wage model in terms of absolute value. Naturally the question is: why do we have this difference? The answer can be seen in the figures of the impulse response functions. Note again that all the lowercase variables represent growth rates, not a level amounts. In Figure 2 and Figure 3 we assume that monetary policy is executed in period 1.

It is easy to see that the diagrams in Figures 2 and 3 are quite different, even though the difference in the assumptions is only one thing: the determination process of wages. Let us start with the interpretation of the figures for p. In case of the union-negotiation model, p only increases while in the minimum-wage model, it goes up and down. This is because in the case of the former, the wage level is re-set at the beginning of the next period. So if there is any monetary shock in the preceding period, the shock would have an impact on the next period's wage level.

Figure 1: Impulse Response Functions of the Union-Negotiation Model

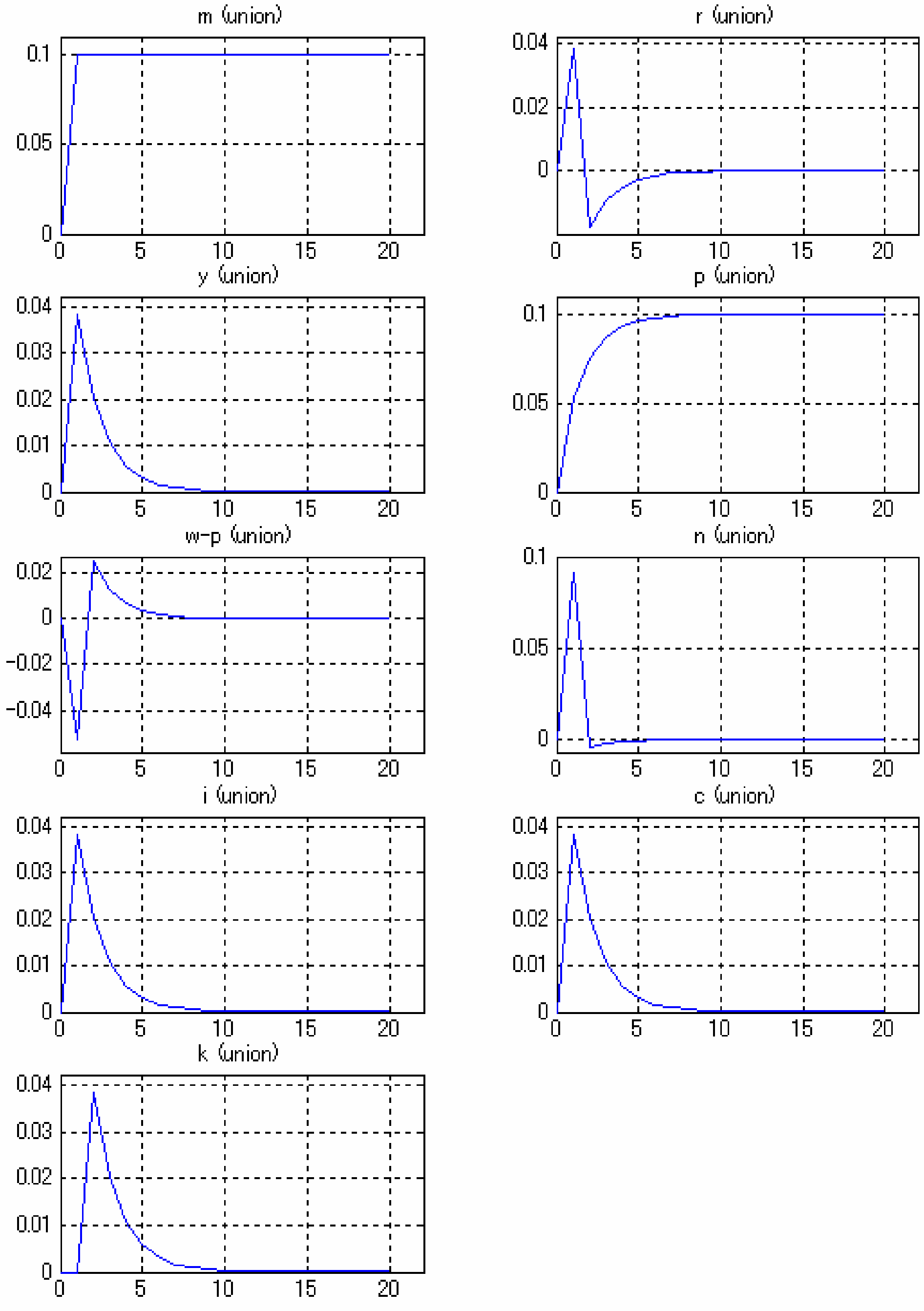
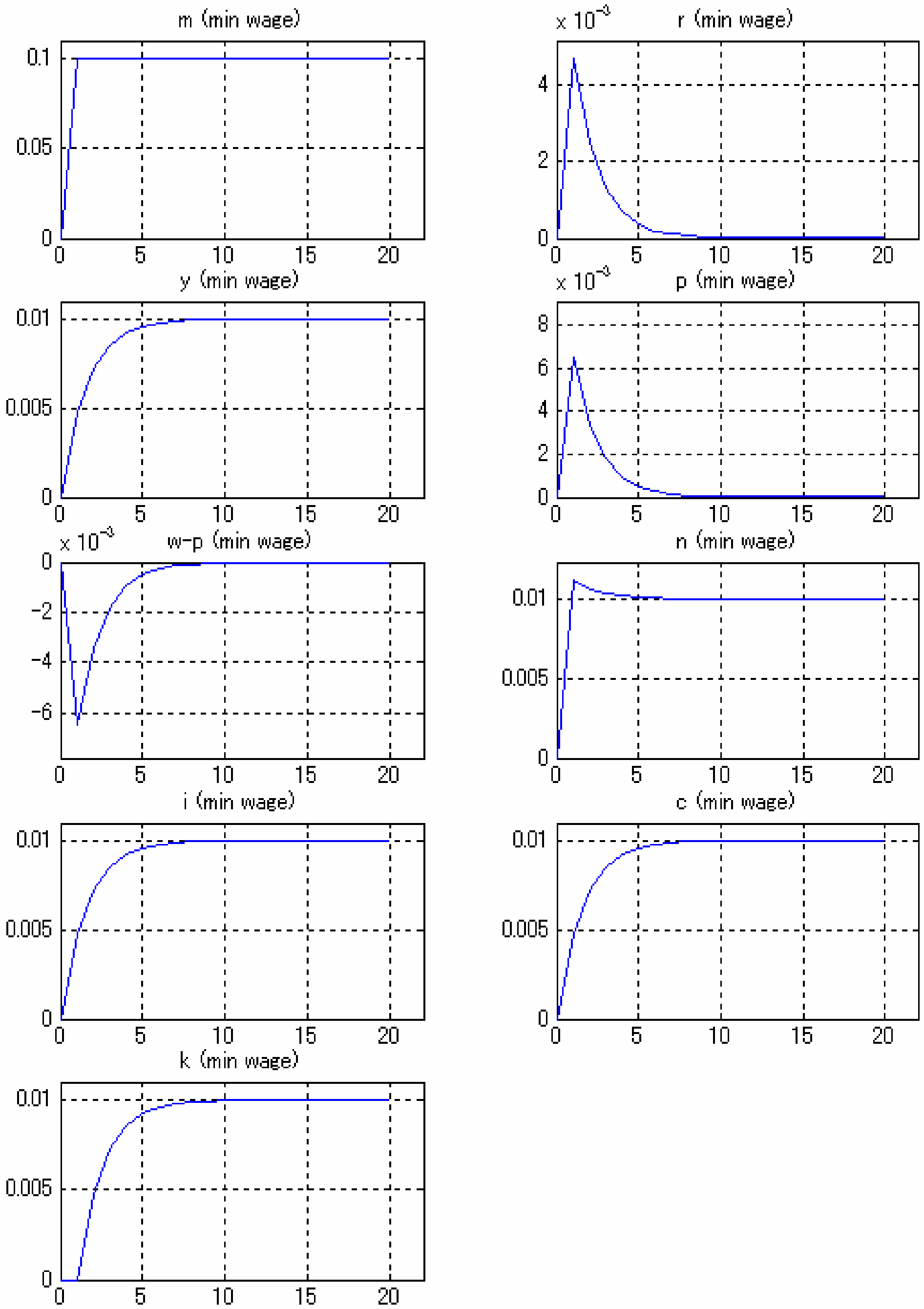


Figure 2: Impulse Response Functions of the Minimum-Wage Model



On the other hand, in the minimum-wage model, wages are fixed at the minimum-wage level and do not change even if some monetary shock occurs. Therefore p is not pushed up by wages even in the periods following a shock period. This difference accounts for the difference in the w-p diagrams. In the minimum-wage w-p diagram, w-p takes only negative numbers. Remember that w-p is the growth rate of W/P. This means that the level value of W/P, the real wage, only decreases. w-p in the union-negotiation model takes a negative number right after the shock period, but it turns positive in the next period. This means that in the minimum-wage model, a monetary shock lowers the real wage indefinitely until there is an opposite monetary shock, while in the union-negotiation model, a monetary shock will lower the real wage only in the shock period. This difference is the key to understand the large difference between the results of these two model.

In the minimum-wage model, after a monetary shock, company managers expect that the real wage will decline until there is an opposite monetary shock. Therefore they increase the input of labor not only in the shock period but also in the succeeding periods. The continuous expansion of labor demand pushes up the marginal product of capital, therefore managers will also invest in the succeeding periods. As a result, Y goes up and raises C. In case of the union-negotiation model, after a monetary shock, company managers expect that the real wage will decline only in the monetary shock period. Therefore they hire a lot of workers in the shock period but not in the future periods. These differences produce rather different results. Monetary shock in union-negotiation model causes large changes in the variables in the shock period, but the changes do not persist. In the minimum wage model, monetary shock dose not cause large changes in the variables in the shock period, but the influence of the shock is quite persistent.

5. Conclusions

In this study we examined the effectiveness of monetary policy in the case of a binding minimum wage which can often be seen in developing countries. The results of simulations based on a DGE model showed that the monetary-policy effect in a binding-minimum-wage economy is relatively small and quite persistent. This finding suggests that these characteristics of monetary policy in the minimum-wage model are quite different from those in the union-negotiation model which is often assumed to account for industrial economies.

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