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Abstract

We examine the economic effects of an acceleration of production relocation by using a dynamic, two-country model based on Obstfeld and Rogoff (1995). Our analysis shows that production relocation depreciates the currency and decreases the production (national income) in the home country during any period; however, we also find that it does not change the short-run employment levels in either country. Moreover, contrary to our conventional wisdom, production relocation does not change the level of the home current account in our model.

Key words: production relocation, current account, exchange rate, employment, new open economy macroeconomics

JEL Classification Numbers: F23, F41

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Introduction

Foreign direct investment has been drastically increasing all over the world since the mid 1980s. A large number of Japanese firms have moved their production location to other Asian countries, hence many economists worry about "hollowing out of the industry" in Japan. They are especially concerned about a sharp increase trend in imports from China recently, because they believe that it may be caused by the rapid and large-scale production relocation to China.

The phenomenon known as hollowing out of the industry usually implies a change for the worse in level of production, employment and current account. A relationship between foreign direct investment (with production relocation) and current account was suggested by the *Annual Report on Japanese Economy and Public Finance 2001-2002* (2002)[1], which suggested that the anxiety about the hollowing out of Japanese industry is based on the fear of a worsening in current account caused by weakened competitive exporting power in recent years. Certainly, the Japanese current account surplus has shown a downward trend from 1998 to 2001, but it has recovered from 2001 in spite of an upward trend in the ratio of overseas production in manufacturing industries. How, then, can we grasp the relationship between production relocation and current account? Do the Japanese current account, production and employment suffer from an acceleration of production relocation? To answer these questions, we have to clarify the relationship between production relocation and some macroeconomic valuables.

A number of theoretical works about the behavior of multinational firms and foreign direct investment have been presented (e.g., Markusen, 1984; Helpman, 1984, 1985; Helpman and Krugman, 1985; Horstman and Markusen, 1992; Brainard, 1993).[2] However, the subject has

[1] See Cabinet Office, Government of Japan (2002).
[2] The Markusen and Mascus (2001) survey concentrates on the general-equilibrium

mainly been discussed in the context of trade theory, hence these studies cannot provide answers to the questions we posed. Therefore, we construct an open-economy macroeconomic model to examine the economic effects of production relocation.

This paper is organized as follows. In Section 1, we present a dynamic, two-country framework that contains a production relocation mechanism. The structure of our model is based on a model of Obstfeld and Rogoff (1995). We examine the nature of the short-run and long-run equilibrium in section 2. Section 3 examines economic effects of a permanent increase in production relocation. We show that an acceleration of production relocation does not change the level of the home current account. Moreover, we find that it must decrease (increase) domestic (foreign) production and consumption in both the short run and the long run; however, it does not change short-run employment levels in either country. Finally, the last section provides some concluding remarks.

1. The model

1.1. Households

There are two countries in a world. Each household in each country consumes a group of differentiated goods. We assume that the number of home households is indexed by interval $[b,1]$ and the number of foreign households is indexed by interval $[0,b]$. The utility function of home household j ($j \in [b,1]$) is

$$U_t^j = \sum_{s=t}^{\infty} \delta^{s-t} \left\{ \ln C_s^j + \chi \ln\left(\frac{M_s^j}{P_s}\right) - \left(\frac{k}{2}\right)\left(L_s^j\right)^2 \right\}, \quad 0 < \delta < 1, \chi > 0, k > 0. \tag{1}$$

Note that households of a country derive utility only from their country's currency. The consumption index is given by

$$C^j = \left\{ \int_0^1 c^j(x)^{\rho} dx \right\}^{\frac{1}{\rho}}, \qquad 0 < \rho < 1. \tag{2}$$

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trade-theory view of the multinational firms.

Here $c^j(x)$ is a home household's consumption of good x. M_{t-1}^j is a money holding of a household at the beginning of period t, and L is the labor supply. The home country price index P is

$$P = \left\{ \int_0^1 p(x)^{\frac{\rho}{\rho-1}} dx \right\}^{\frac{\rho-1}{\rho}}. \tag{3}$$

The household's period budget constraint is

$$F_t^j + \frac{M_t^j}{P_t} = (1 + r_{t-1}) F_{t-1}^j + \frac{M_{t-1}^j}{P_t} + \frac{\pi_t(j) + w_t L_t^j}{P_t} - C_t^j + \tau_t^j, \tag{4}$$

where r_{t-1} is the real interest rate earned on bonds between periods $t-1$ and t. F_{t-1} is the stock of bonds at the beginning of period t. π shows the firm's profit, w is the nominal wage rate and τ is the transfer from the domestic government. The situations of foreign households are analogous. Define nominal interest rates of both countries on period t by

$$1 + i_t = \left(\frac{P_{t+1}}{P_t} \right)(1 + r_t), \quad 1 + i_t^* = \left(\frac{P_{t+1}^*}{P_t^*} \right)(1 + r_t^*). \tag{5a, b}$$

Foreign variables are represented with an asterisk. If purchasing power parity (PPP) holds, the equity of real interest rate (r_t and r_t^*) implies uncovered interest parity as follows[3]:

$$1 + i_t = \left(\frac{e_{t+1}}{e_t} \right)(1 + i_t^*). \tag{6}$$

The first-order conditions for utility maximization problems are

$$C_{t+1} = \delta\,(1 + r_t)\,C_t, \quad C_{t+1}^* = \delta\,(1 + r_t^*)\,C_t^*, \tag{7a, b}$$

$$\frac{M_t}{P_t} = \chi \left(\frac{1 + i_t}{i_t} \right) C_t, \quad \frac{M_t^*}{P_t^*} = \chi \left(\frac{1 + i_t^*}{i_t^*} \right) C_t^*, \tag{8a, b}$$

$$\kappa\, L_t = (1 - b)^2 \left(\frac{w_t}{P_t\, C_t} \right), \quad \kappa\, L_t^* = b^2 \left(\frac{w_t^*}{P_t^*\, C_t^*} \right). \tag{9a, b}$$

We should note that (7a)-(9b) are not the optimal conditions of individual households but the

[3] We find that PPP must hold in our model in section 1 (equation (14)). However, if we assume a "pricing-to-market (PTM)" behavior, instead of our "producer's currency pricing (PCP)" setting, PPP doesn't come into existence.

aggregated optimal conditions under the assumption that behaviors of all households are symmetric. Therefore, we don't need to express " j " in these equations.

1.2. Firms

We assume that all goods are tradable and firms do not remit their profits to the home country. The goods indexed by interval $[\alpha,1]$ are produced in the home country and the rest of them ($x \in [0,\alpha]$) are produced in the foreign country. However, the $[\beta,1]$ goods are produced by home firms, and the $[0,\beta]$ goods are produced by foreign firms. In this case, the $[\beta,\alpha]$ goods are produced by the home multinational firms in a foreign country ($\beta < \alpha$).

We assume that labor is the only input used to produce goods, with its amount given as $l = c + c^*$. The profit function of the firm, which produces good x in the home country, is given by

$$\pi(x) = p(x)\,c(x) + e\;p^*(x)\,c^*(x) - w\left(c(x) + c^*(x)\right), \quad x \in [\alpha,1], \tag{10}$$

where,[4]

$$c(x) = \left\{\frac{p(x)}{P}\right\}^{\frac{1}{\rho-1}} C, \quad c^*(x) = \left\{\frac{p^*(x)}{P^*}\right\}^{\frac{1}{\rho-1}} C^*. \tag{11a, b}$$

Here we omit writing the subscript t for simplicity. Each firm takes its wage rate as a given, choosing the optimal price as follows:

$$p(x) = \frac{w}{\rho} \equiv p^H, \quad p^*(x) = \frac{w}{e\rho} \equiv p^{H*}, \qquad x \in [\alpha,1]. \tag{12a, b}$$

All firms in the foreign country strive similarly to maximize profit, and we have

$$p(x) = \frac{ew^*}{\rho} \equiv p^F, \quad p^*(x) = \frac{w^*}{\rho} \equiv p^{F*}, \qquad x \in [0,\alpha]. \tag{12c, d}$$

Subscripts H and F in (12a)-(12d) show the country where the goods are produced. For instance, p^{H*} is the price of goods produced at home and sold in the foreign country.

[4] For the derivation of an individual's demand for good x, see Obstfeld and Rogoff (1996).

Substituting (12a)-(12d) into price indexes ((3) and its foreign counterpart), we have

$$P = \left\{ \alpha \left(e\, p^{F*} \right)^{\frac{\rho}{\rho-1}} + (1-\alpha) \left(p^{H} \right)^{\frac{\rho}{\rho-1}} \right\}^{\frac{\rho-1}{\rho}}, \tag{13a}$$

$$P^{*} = \left\{ \alpha \left(p^{F*} \right)^{\frac{\rho}{\rho-1}} + (1-\alpha) \left(\frac{p^{H}}{e} \right)^{\frac{\rho}{\rho-1}} \right\}^{\frac{\rho-1}{\rho}}, \tag{13b}$$

where e is the nominal exchange rate. Using (13a) and (13b), we have

$$P = eP^{*}. \tag{14}$$

1.3. Governments

Transfer to the private sector is completely financed by seigniorage in each country. The government budget constraints are then

$$\tau_t = \frac{M_t - M_{t-1}}{P_t}, \quad \tau_t^{*} = \frac{M_t^{*} - M_{t-1}^{*}}{P_t^{*}}. \tag{15a, b}$$

1.4. Goods and labor market equilibrium

The goods market equilibrium conditions are shown as follows:

$$y = (1-\alpha)\left(\frac{p^{H}}{P} \right)^{\frac{\rho}{\rho-1}} \left(C + C^{*} \right), \quad y^{*} = \alpha \left(\frac{p^{F*}}{P^{*}} \right)^{\frac{\rho}{\rho-1}} \left(C + C^{*} \right). \tag{16a, b}$$

Note that $y \equiv p^{H} Y / P$ ($y^{*} \equiv p^{F*} Y^{*} / P^{*}$). Y (Y^{*}) is the output. Considering the definition of y (y^{*}) and using (9a), (9b), (12a), (12d) and production function $Y = L$, we obtain the following labor market equilibrium conditions:

$$\kappa\, y = (1-b)^{2} \left(\frac{p^{H}}{P} \right)^{2} \left(\frac{\rho}{C} \right), \quad \kappa\, y^{*} = b^{2} \left(\frac{p^{F*}}{P^{*}} \right)^{2} \left(\frac{\rho}{C^{*}} \right). \tag{17a, b}$$

2. Steady state

2.1. A symmetric steady state

We can derive the world steady-state real interest rate by using (7a) and (7b) as follows:

$$\bar{r} = \bar{r}^* = \frac{1-\delta}{\delta} \equiv \omega. \tag{18}$$

The steady-state values are marked by overbars. Considering an aggregated version of (4) and (10) in each economy and using (11a)-(12d), (15a)-(16b) and the production function, we have

$$\overline{C} = \bar{r}\ \overline{F} + \bar{y}, \quad \overline{C}^* = -\bar{r}\ \overline{F} + \bar{y}^*, \tag{19a, b}$$

where (19b) makes use of

$$F + F^* = 0. \tag{20}$$

This shows that the world net foreign assets must be zero. We now assume that net foreign assets are zero in the initial steady state ($\overline{F}_0 = \overline{F}_0^* = 0$) to obtain a closed-form solution of this model. Moreover, we assume that $\alpha_0 = b$ in the initial period. The particular steady state is shown by zero subscripts. In this case, we can find that $\overline{C}_0 = \bar{y}_0$ and $\overline{C}_0^* = \bar{y}_0^*$ from (19a) and (19b). Therefore, considering (16a) and (16b), we have

$$\frac{\bar{y}_0}{\bar{y}_0^*} = \left(\frac{1-\alpha_0}{\alpha_0}\right)\left(\frac{\bar{p}_0^H / \overline{P}_0}{\bar{p}_0^{F*} / \overline{P}_0^*}\right)^{\frac{\rho}{\rho-1}}. \tag{19c}$$

Next, considering $\overline{C}_0 = \bar{y}_0$ and $\overline{C}_0^* = \bar{y}_0^*$, and using (17a) and (17b), we can derive

$$\frac{\bar{y}_0}{\bar{y}_0^*} = \left(\frac{1-b}{b}\right)\left(\frac{\bar{p}_0^H / \overline{P}_0}{\bar{p}_0^{F*} / \overline{P}_0^*}\right). \tag{19d}$$

Using (19c), (19d) and $\alpha_0 = b$, we have $\bar{p}_0^H / \overline{P}_0 = \bar{p}_0^{F*} / \overline{P}_0^*$ in the initial steady state. Considering this equation, price index (13a) (or (13b)) and (14), we have $\bar{p}_0^H / \overline{P}_0 = \bar{p}_0^{F*} / \overline{P}_0^* = 1$. Therefore, using $\overline{C}_0 = \bar{y}_0$, $\overline{C}_0^* = \bar{y}_0^*$, (17a) and (17b), we obtain

$$\overline{C}_0 = \bar{y}_0 = (1-b)\left(\frac{\rho}{\kappa}\right)^{\frac{1}{2}}, \quad \overline{C}_0^* = \bar{y}_0^* = b\left(\frac{\rho}{\kappa}\right)^{\frac{1}{2}}. \tag{21a, b}$$

Moreover, using (5a), (5b), (8a), (8b), (14), (18), (21a) and (21b), we can derive

$$\bar{e}_0 = \left(\frac{b}{1-b}\right)\left(\frac{\overline{M}_0}{\overline{M}_0^*}\right). \tag{21c}$$

2.2. A long-run equilibrium

In our model, unanticipated shock (an increase in production relocation) in the goods market occurs on the period t.[5] Prices p^H and p^{F*} are set a period in advance but are adjusted after one period, because firms cannot respond to this shock within the period t. We call the period t a "short-run" period and periods after $t+1$ "long-run" periods. The long-run equilibrium conditions are shown as follows:

$$C_{t+2} = \delta\left(1+r_{t+1}\right)C_{t+1}, \quad C_{t+2}^* = \delta\left(1+r_{t+1}^*\right)C_{t+1}^*, \tag{22a, b}$$

$$\frac{M_{t+1}}{P_{t+1}} = \chi\left(\frac{1+i_{t+1}}{i_{t+1}}\right)C_{t+1}, \quad \frac{M_{t+1}^*}{P_{t+1}^*} = \chi\left(\frac{1+i_{t+1}^*}{i_{t+1}^*}\right)C_{t+1}^*, \tag{22c, d}$$

$$\kappa\, y_{t+1} = (1-b)^2\left(\frac{p_{t+1}^H}{P_{t+1}}\right)^2\left(\frac{\rho}{C_{t+1}}\right), \quad \kappa\, y_{t+1}^* = b^2\left(\frac{p_{t+1}^{F*}}{P_{t+1}^*}\right)^2\left(\frac{\rho}{C_{t+1}^*}\right), \tag{22e, f}$$

$$y_{t+1} = \left(1-\alpha_{t+1}\right)\left(\frac{p_{t+1}^H}{P_{t+1}}\right)^{\frac{\rho}{\rho-1}}\left(C_{t+1}+C_{t+1}^*\right), \tag{22g}$$

$$y_{t+1}^* = \alpha_{t+1}\left(\frac{p_{t+1}^{F*}}{P_{t+1}^*}\right)^{\frac{\rho}{\rho-1}}\left(C_{t+1}+C_{t+1}^*\right), \tag{22h}$$

$$F_{t+1} - F_t = r_t\, F_t + y_{t+1} - C_{t+1}, \quad F_{t+1}^* - F_t^* = r_t^*\, F_t^* + y_{t+1}^* - C_{t+1}^*, \tag{22i, j}$$

$$P_{t+1} = e_{t+1}P_{t+1}^*, \tag{22k}$$

$$P_{t+1} = \left\{\alpha_{t+1}\left(e_{t+1}p_{t+1}^{F*}\right)^{\frac{\rho}{\rho-1}} + \left(1-\alpha_{t+1}\right)\left(p_{t+1}^H\right)^{\frac{\rho}{\rho-1}}\right\}^{\frac{\rho-1}{\rho}}, \tag{22l}$$

$$P_{t+1}^* = \left\{\alpha_{t+1}\left(p_{t+1}^{F*}\right)^{\frac{\rho}{\rho-1}} + \left(1-\alpha_{t+1}\right)\left(\frac{p_{t+1}^H}{e_{t+1}}\right)^{\frac{\rho}{\rho-1}}\right\}^{\frac{\rho-1}{\rho}}. \tag{22m}$$

(22a) and (22b) are consumption Euler equations. (22c) and (22d) are money market clearing

[5] We consider the effects of a permanent increase in production relocation in our model. We assume that $\hat{\alpha}_t = \hat{\alpha}_{t+1}$ for simplicity.

conditions. (22e) and (22f) are labor market clearing conditions. (22g) and (22h) are goods market clearing conditions. (22i) and (22j) are national budget constraints (balance of payments equations). We stress that F_t is determined on period “t”, but this shows the stock of bonds at the beginning of period “$t+1$”. (22k) shows that PPP comes into existence, and (22l) and (22m) are price indexes. We now solve this model by linear approximation around the initial zero-shock equilibrium with $\overline{F}_0 = \overline{F}_0^* = 0$ and $\alpha_0 = b$, and we have (23) and (24). Equation (23) comes from the money market equilibrium conditions and (24) comes from the goods market, labor market and balance of payment equilibrium conditions in the long run (see Appendix A). $\hat{X} \equiv dX/\overline{X}_0$ for any variable X, and $\overline{X}_0$ is the zero-shock equilibrium value. However, we assume that $\hat{F} \equiv dF/\overline{C}_0$ only about F, because $\overline{F}_0 = 0$.

$$\hat{e}_{t+1} = -\left(\hat{C}_{t+1} - \hat{C}_{t+1}^*\right). \tag{23}$$

$$\hat{C}_{t+1} - \hat{C}_{t+1}^* = \left(\frac{2-\rho}{2}\right)\left(\frac{\omega}{b}\right)\hat{F}_t + (\rho-1)\left(\frac{1}{1-\alpha_0}\right)\hat{\alpha}_{t+1}. \tag{24}$$

2.3. A short-run equilibrium

The following equations show the short-run equilibrium.

$$C_{t+1} = \delta\left(1+r_t\right)C_t, \quad C_{t+1}^* = \delta\left(1+r_t^*\right)C_t^*, \tag{25a, b}$$

$$\frac{M_t}{P_t} = \chi\left(\frac{1+i_t}{i_t}\right)C_t, \quad \frac{M_t^*}{P_t^*} = \chi\left(\frac{1+i_t^*}{i_t^*}\right)C_t^*, \tag{25c, d}$$

$$1+i_t = \left(\frac{P_{t+1}}{P_t}\right)\left(1+r_t\right), \quad 1+i_t^* = \left(\frac{P_{t+1}^*}{P_t^*}\right)\left(1+r_t^*\right), \tag{25e, f}$$

$$y_t = \left(1-\alpha_t\right)\left(\frac{p_t^H}{P_t}\right)^{\frac{\rho}{\rho-1}}\left(C_t + C_t^*\right), \quad y_t^* = \alpha_t\left(\frac{p_t^{F*}}{P_t^*}\right)^{\frac{\rho}{\rho-1}}\left(C_t + C_t^*\right), \tag{25g, h}$$

$$F_t - F_{t-1} = r_{t-1}F_{t-1} + y_t - C_t, \quad F_t^* - F_{t-1}^* = r_{t-1}^*F_{t-1}^* + y_t^* - C_t^*, \tag{25i, j}$$

$$P_t = e_tP_t^*, \tag{25k}$$

$$P_t = \left\{ \alpha_t \left(e_t p_t^{F*} \right)^{\frac{\rho}{\rho-1}} + (1-\alpha_t)\left(p_t^H \right)^{\frac{\rho}{\rho-1}} \right\}^{\frac{\rho-1}{\rho}}, \tag{25l}$$

$$P_t^* = \left\{ \alpha_t \left(p_t^{F*} \right)^{\frac{\rho}{\rho-1}} + (1-\alpha_t)\left(\frac{p_t^H}{e_t} \right)^{\frac{\rho}{\rho-1}} \right\}^{\frac{\rho-1}{\rho}}. \tag{25m}$$

Note that labor market equilibrium ((22e) and (22f) in the long-run equilibrium,) does not come into existence in the short-run situation, because of the price rigidity.

3. Effects of permanent increase in production relocation

Using the log-linearized version of equations (25a)-(25m) and considering some long-run equilibrium conditions, we have the following conditions (see Appendix B):

$$\hat{e}_t = -\left(\hat{C}_t - \hat{C}_t^* \right). \tag{26}$$

$$\hat{e}_t = -\left(\frac{\rho-1}{\rho} \right)\left[\left\{ 1 + \frac{2(1-\rho)}{(2-\rho)\omega} \right\}\left(\frac{1}{1-\alpha_0} \right)\hat{\alpha}_t + \left\{ 1 + \frac{2}{(2-\rho)\omega} \right\}\left(\hat{C}_t - \hat{C}_t^* \right) \right]. \tag{27}$$

The effects of production relocation on relative consumption and exchange rate can be calculated by using (26) and (27), as follows:

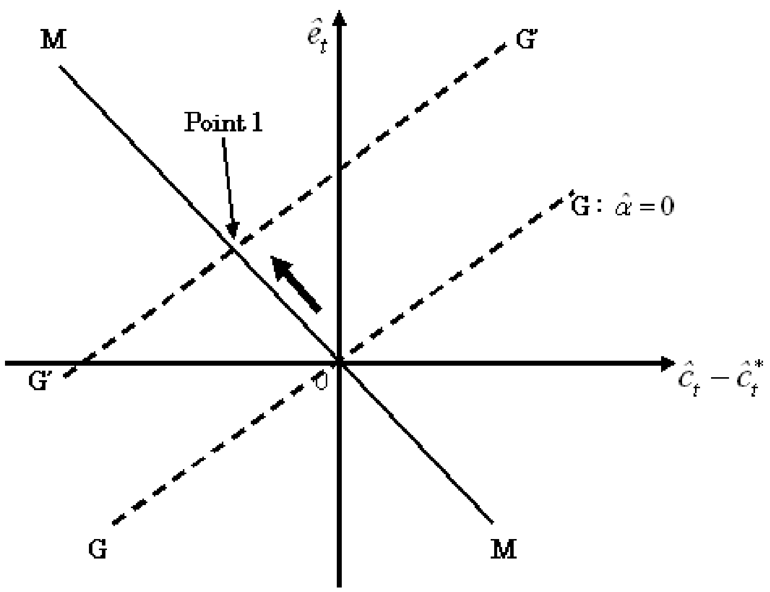
$$\hat{C}_t - \hat{C}_t^* = (\rho-1)\left(\frac{1}{1-\alpha_0} \right)\hat{\alpha}_t < 0. \tag{28}$$

$$\hat{e}_t = -(\rho-1)\left(\frac{1}{1-\alpha_0} \right)\hat{\alpha}_t > 0. \tag{29}$$

Figure 1 illustrates these effects. Now, we call (26) the “MM schedule” and (27) the “GG schedule”. The MM schedule slopes downward because relative domestic money demand rises as relative domestic consumption rises. The GG schedule slopes upward because the domestic currency depreciation is needed to raise $\hat{y}_t - \hat{y}_t^*$ enough to justify a rise in $\hat{C}_t - \hat{C}_t^*$. If production relocation does not exist ($\hat{\alpha}_t = \hat{\alpha}_{t+1} = 0$), the GG schedule passes through the origin. The advance in production relocation shifts the GG schedule to the left-hand side, and the equilibrium point shifts from the origin to point 1 in Figure 1; in other words, the level of

$\hat{e}_t$ rises and the level of $\hat{C}_t - \hat{C}_t^*$ decreases as an acceleration of production relocation. We now interpret these results intuitively. Relative consumption is directly decreased by an increase in α, because an acceleration of production relocation itself has a contractive effect on domestic national income and an expansive effect on foreign national income. We call this the "production relocation effect".[6] The decrease in relative domestic income by production relocation lowers the domestic money demand level, and the domestic price rises to maintain the money market equilibrium. Hence, an increase in α leads to a rise in $\hat{e}_t$ (depreciation of home currency).

Figure 1. Effects of a permanent increase in production relocation



Using (28), (29) and (B17) in Appendix B, we have

[6] It seems that an increase in α affects to the economy through the variation of price index (see (25l) and (25m)) besides the production relocation effect, but an increase in α does not affect the price "directly" in this model, because $\overline{p}_0^H / \overline{P}_0 = \overline{p}_0^{F*} / \overline{P}_0^* = 1$ in the initial steady state.

$$\left(\frac{1}{b}\right)\hat{F}_t = 0. \tag{30}$$

A permanent increase in α does not affect the home current account. Why do we have this "curious" result? First, an increase in α decreases the home relative consumption on period t (see equation (28)). Moreover, the advance of production relocation increases demand for domestic goods through an increase in P (a decrease in P^*), and the home relative national income increases. These effects improve the home current account. On the other hand, production relocation itself has a contractive effect on domestic production (national income), and this effect worsens the current account. However, these effects completely cancel each other out; therefore, an acceleration of production relocation does not affect the current account.

Proposition 1. An increase in α leads to both improvement and worsening of the home current account, and these opposite effects completely cancel each other out. Therefore, production relocation does not affect the level of the current account.

The effect of an acceleration of production relocation on the relative national income (production) can be derived by using (B9), (B10), (28) and (30):

$$\hat{y}_t - \hat{y}_t^* = \hat{C}_t - \hat{C}_t^* = (\rho - 1)\left(\frac{1}{1-\alpha_0}\right)\hat{\alpha}_t < 0. \tag{31}$$

Moreover, using (30), (31), (A14), (B1), (B2) and $\hat{\alpha}_t = \hat{\alpha}_{t+1}$, we have

$$\hat{y}_{t+1} - \hat{y}_{t+1}^* = \hat{C}_{t+1} - \hat{C}_{t+1}^* = \hat{y}_t - \hat{y}_t^* = \hat{C}_t - \hat{C}_t^* < 0. \tag{32}$$

We now find that an acceleration of production relocation lowers the relative income (production) level in both the short run and the long run.

We examine the effects on individual valuables. Using (A3)-(A6) and (A10) in the long-run equilibrium, we can derive

$$\hat{y}^W_{t+1} = \hat{C}^W_{t+1} = 0, \tag{33}$$

where $\hat{X}^W \equiv (1-\alpha_0)\hat{X} + \alpha_0 \hat{X}^*$ for valuable X. Next, using (A1), (A2), (B1)-(B8) and (B12), we have

$$\hat{y}^W_t = \hat{C}^W_t = 0. \tag{34}$$

From (31)-(34), we can derive

$$\hat{y}_{t+1} = \hat{y}_t = \hat{C}_{t+1} = \hat{C}_t = (\rho - 1)\left(\frac{\alpha_0}{1-\alpha_0}\right)\hat{\alpha}_t < 0, \tag{35a}$$

$$\hat{y}^*_{t+1} = \hat{y}^*_t = \hat{C}^*_{t+1} = \hat{C}^*_t = -(\rho - 1)\hat{\alpha}_t > 0. \tag{35b}$$

Production relocation lowers (raises) the level of domestic (foreign) production and consumption in both the short run and the long run. These effects are mainly caused by the "production relocation effect". Finally, the effect on the level of employment is derived by using (9a), (9b), (26), (34), (B11) and (B12) as follows:

$$\hat{L}_t = \hat{L}^W_t + \alpha_0\left(\hat{L}_t - \hat{L}^*_t\right) = 0, \quad \hat{L}^*_t = \hat{L}^W_t - (1-\alpha_0)\left(\hat{L}_t - \hat{L}^*_t\right) = 0. \tag{36a, b}$$

Surprisingly, we can find that an increase in α does not change the employment level.

Proposition 2. An acceleration of production relocation does not affect the short-run employment level in either country. This is because the effect of an increase in α on employment through the consumption variation is completely offset by the effect caused by the depreciation of the home currency in each economy.

4. Conclusion

In this paper, we have examined the effects of production relocation on home and foreign economies using a dynamic, two-country model. Our analysis shows that an acceleration of production relocation leads to the depreciation of home currency. Moreover, it decreases (increases) domestic (foreign) production and consumption in both the short run and the long run, but it does not change the short-run employment level in either country. These results suggest that an acceleration of production relocation may be an important phenomenon for understanding the international macroeconomic fluctuations.

We also refer to the effect of an increase in α on the current account. As we noted above, many Japanese economists are anxious about the worsening in the current account of Japan caused by an increase in offshore production. However, contrary to the conventional wisdom, we find that an acceleration of production relocation does not change the level of the current account in our analysis.

Appendix A: Long-run equilibrium conditions

We can derive that $\bar{r} = \bar{r}^* = \dfrac{1-\delta}{\delta} \equiv \omega$ in the steady state from (22a) and (22b). Next, we log-linearize the long-run equilibrium conditions:

$$-\hat{P}_{t+1} = \hat{C}_{t+1}, \quad -\hat{P}^*_{t+1} = \hat{C}^*_{t+1}, \tag{A1, 2}$$

$$\hat{y}_{t+1} = 2\left(\hat{p}^H_{t+1} - \hat{P}_{t+1}\right) - \hat{C}_{t+1}, \quad \hat{y}^*_{t+1} = 2\left(\hat{p}^{F*}_{t+1} - \hat{P}^*_{t+1}\right) - \hat{C}^*_{t+1}, \tag{A3, 4}$$

$$\hat{y}_{t+1} = -\left(\frac{\alpha_0}{1-\alpha_0}\right)\hat{\alpha}_{t+1} + \left(\frac{\rho}{\rho-1}\right)\left(\hat{p}^H_{t+1} - \hat{P}_{t+1}\right) + (1-b)\,\hat{C}_{t+1} + b\,\hat{C}^*_{t+1}, \tag{A5}$$

$$\hat{y}^*_{t+1} = \hat{\alpha}_{t+1} + \left(\frac{\rho}{\rho-1}\right)\left(\hat{p}^{F*}_{t+1} - \hat{P}^*_{t+1}\right) + (1-b)\,\hat{C}_{t+1} + b\,\hat{C}^*_{t+1}, \tag{A6}$$

$$\omega\,\hat{F}_t = -\hat{y}_{t+1} + \hat{C}_{t+1}, \quad \left(\frac{1-b}{b}\right)\omega\,\hat{F}_t = \hat{y}^*_{t+1} - \hat{C}^*_{t+1}, \tag{A7, 8}$$

$$\hat{P}_{t+1} = \hat{e}_{t+1} + \hat{P}^*_{t+1}, \tag{A9}$$

$$\alpha_0\left(\hat{p}^{F*}_{t+1} - \hat{P}^*_{t+1}\right) + (1-\alpha_0)\left(\hat{p}^H_{t+1} - \hat{P}_{t+1}\right) = 0, \tag{A10}$$

where we assume that $\hat{X} \equiv dX/\bar{X}_0$ for valuable X, but only for stock of bonds, we assume that $\hat{F} \equiv dF/\bar{C}_0$, because $\bar{F}_0 = 0$. Using (A1), (A2) and (A9), we have

$$\hat{e}_{t+1} = -\left(\hat{C}_{t+1} - \hat{C}^*_{t+1}\right). \tag{23}$$

Next, we can derive

$$\hat{C}_{t+1}-\hat{C}^*_{t+1}=\left(\frac{\omega}{b}\right)\hat{F}_t+\left(\hat{y}_{t+1}-\hat{y}^*_{t+1}\right), \tag{A11}$$

by using (A7) and (A8). From (A3) and (A4), we have

$$\hat{y}_{t+1}-\hat{y}^*_{t+1}=2\left\{\left(\hat{p}^H_{t+1}-\hat{P}_{t+1}\right)-\left(\hat{p}^{F*}_{t+1}-\hat{P}^*_{t+1}\right)\right\}-\left(\hat{C}_{t+1}-\hat{C}^*_{t+1}\right). \tag{A12}$$

Moreover, we derive

$$\hat{y}_{t+1}-\hat{y}^*_{t+1}=-\left(\frac{1}{1-\alpha_0}\right)\hat{\alpha}_{t+1}+\left(\frac{\rho}{\rho-1}\right)\left\{\left(\hat{p}^H_{t+1}-\hat{P}_{t+1}\right)-\left(\hat{p}^{F*}_{t+1}-\hat{P}^*_{t+1}\right)\right\}, \tag{A13}$$

by using (A5) and (A6). Now, from (A11)-(A13), we obtain

$$\hat{C}_{t+1}-\hat{C}^*_{t+1}=\left(\frac{2-\rho}{2}\right)\left(\frac{\omega}{b}\right)\hat{F}_t+\left(\rho-1\right)\left(\frac{1}{1-\alpha_0}\right)\hat{\alpha}_{t+1}. \tag{24}$$

Finally, we can derive the following equation by using (A12), (A13) and (24):

$$\hat{y}_{t+1}-\hat{y}^*_{t+1}=\left(\rho-1\right)\left(\frac{1}{1-\alpha_0}\right)\hat{\alpha}_{t+1}-\left(\frac{\rho}{2}\right)\left(\frac{\omega}{b}\right)\hat{F}_t. \tag{A14}$$

Appendix B: Short-run equilibrium conditions

The log-linearized version of (25a)-(25l) is shown as follows (we can also derive (B12) by using (25m)):

$$\hat{C}_{t+1}=\hat{C}_t+\left(\frac{\omega}{1+\omega}\right)\hat{r}_t,\quad \hat{C}^*_{t+1}=\hat{C}^*_t+\left(\frac{\omega}{1+\omega}\right)\hat{r}_t, \tag{B1, 2}$$

$$-\hat{P}_t=\hat{C}_t-\left(\frac{1}{1+\omega}\right)\hat{i}_t,\quad -\hat{P}^*_t=\hat{C}^*_t-\left(\frac{1}{1+\omega}\right)\hat{i}^*_t, \tag{B3, 4}$$

$$\left(\frac{\omega}{1+\omega}\right)\hat{r}_t=\left(\frac{\omega}{1+\omega}\right)\hat{i}_t+\hat{P}_t-\hat{P}_{t+1},\quad \left(\frac{\omega}{1+\omega}\right)\hat{r}_t=\left(\frac{\omega}{1+\omega}\right)\hat{i}^*_t+\hat{P}^*_t-\hat{P}^*_{t+1}, \tag{B5, 6}$$

$$\hat{y}_t=-\left(\frac{\alpha_0}{1-\alpha_0}\right)\hat{\alpha}_t-\left(\frac{\rho}{\rho-1}\right)\hat{P}_t+\left(1-b\right)\hat{C}_t+b\,\hat{C}^*_t, \tag{B7}$$

$$\hat{y}^*_t=\hat{\alpha}_t-\left(\frac{\rho}{\rho-1}\right)\hat{P}^*_t+\left(1-b\right)\hat{C}_t+b\,\hat{C}^*_t, \tag{B8}$$

$$\hat{F}_t=\hat{y}_t-\hat{C}_t,\quad -\left(\frac{1-b}{b}\right)\hat{F}_t=\hat{y}^*_t-\hat{C}^*_t, \tag{B9, 10}$$

$$\hat{P}_t=\hat{e}_t+\hat{P}^*_t, \tag{B11}$$

$$\alpha_0\hat{P}^*_t+\left(1-\alpha_0\right)\hat{P}_t=0. \tag{B12}$$

Note that p^H, p^{F*}, w and w^* are given in the short run.

We now derive the MM and GG schedules. Using (B3), (B4) and (B11), we have

$$-\hat{e}_t = -\left(\frac{1}{1+\omega}\right)\left(\hat{i}_t - \hat{i}_t^*\right) + \left(\hat{C}_t - \hat{C}_t^*\right). \tag{B13}$$

We also derive the following equation (B14) from (B5), (B6) and (B11).

$$\left(\frac{1}{1+\omega}\right)\left(\hat{i}_t - \hat{i}_t^*\right) = \left(\frac{1}{\omega}\right)\left(\hat{e}_{t+1} - \hat{e}_t\right). \tag{B14}$$

Using (B13) and (B14), we can derive the asset market equilibrium condition:

$$-\hat{e}_t = -\left(\frac{1}{\omega}\right)\left(\hat{e}_{t+1} - \hat{e}_t\right) + \left(\hat{C}_t - \hat{C}_t^*\right). \tag{B15}$$

Using (B1) and (B2), we have

$$\hat{C}_{t+1} - \hat{C}_{t+1}^* = \hat{C}_t - \hat{C}_t^*. \tag{B16}$$

We now have the MM schedule by using (23), (B15) and (B16):

$$\hat{e}_t = -\left(\hat{C}_t - \hat{C}_t^*\right). \tag{26}$$

We can find that $\hat{e}_{t+1} = \hat{e}_t$ by using (23), (26) and (B16). This shows that the exchange rate over-shooting does not exist in this model.

Next, we derive the GG schedule. Using (B7)-(B11), we have

$$\left(\frac{1}{b}\right)\hat{F}_t = -\left(\frac{1}{1-\alpha_0}\right)\hat{\alpha}_t - \left(\frac{\rho}{\rho-1}\right)\hat{e}_t - \left(\hat{C}_t - \hat{C}_t^*\right). \tag{B17}$$

Using the budget constraint (in period $t+1$) and (B16), (A11) can be accommodated as

$$\hat{C}_t - \hat{C}_t^* = \left(\frac{\omega}{b}\right)\hat{F}_t + \left(\hat{y}_{t+1} - \hat{y}_{t+1}^*\right).$$

Using this accommodated budget constraint and (A14), we have

$$\hat{C}_t - \hat{C}_t^* = (\rho-1)\left(\frac{1}{1-\alpha_0}\right)\hat{\alpha}_{t+1} + \left(\frac{2-\rho}{2}\right)\left(\frac{\omega}{b}\right)\hat{F}_t. \tag{B18}$$

Now we can derive the GG schedule by using (B17) and (B18):

$$\hat{e}_t = -\left(\frac{\rho-1}{\rho}\right)\left[\left\{1+\frac{2(1-\rho)}{(2-\rho)\omega}\right\}\left(\frac{1}{1-\alpha_0}\right)\hat{\alpha}_t + \left\{1+\frac{2}{(2-\rho)\omega}\right\}\left(\hat{C}_t - \hat{C}_t^*\right)\right]. \tag{27}$$

Note that we use the assumption that $\hat{\alpha}_t = \hat{\alpha}_{t+1}$ in the derivation of (27).

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