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The role of local currency pricing in international transmission effects of monetary and productivity shocks in an economy with vertical production linkage and firm entry

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Abstract

In this paper, we construct a two-country model with the three factors of asymmetry in price-setting behavior between home and foreign intermediate goods firms, vertical production and trade, and endogenous entry of home and foreign final goods firms. We mainly examine the effect of asymmetric price-setting behavior on the welfare effects of monetary and productivity shocks, taking into account firm entry and exit. We show that when the ratio of home and/or foreign intermediate goods firms that set their export prices in the local currency rises, a home monetary shock has a beggar-thy-neighbor effect. In scenarios other than one where the ratios of both countries' intermediate goods firms that set their export prices in the local currency are unity, we show that the two types of home productivity shocks cause foreign welfare to deteriorate. When the ratios of both countries' intermediate goods firms that set their export prices in the local currency are unity, we show that the two types of home productivity shocks have a different effect on foreign welfare.

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1 Introduction

Over the past several decades, interdependence among nations has grown with the deepening of vertical structures of production and trade, which mean vertical production linkages. Hummels et al. (2001) analyze data from 10 OECD and four emerging economies and argue that the vertical structure is an important feature of today's global production and trade.[1] Based on such an empirical analysis, recently, some researches have been conducted by incorporating vertical production and trade into the new open economy macroeconomics (NOEM) model pioneered by Obstfeld and Rogoff (1995). For example, Berger (2006), by incorporating only trade in intermediate inputs into the standard NOEM model,[2] examines the effects of a home monetary shock on the welfare of both countries. He shows that a home monetary shock has (i) a beggar-thyself effect if the interdependence among nations is significantly high and (ii) a prosper-thy-neighbor effect unless the competitiveness of markets is too low. Huang and Liu (2006) examine the effects of a home monetary shock on the welfare of both countries using the stochastic two-country NOEM model with multiple stages of production and trade, taking into account firms' symmetric price-setting behavior. They show that a home monetary shock has a prosper-thyself and prosper-thy-neighbor effect regardless of the firms' price-setting behavior, the greater the number of stages of production, and the more intermediate inputs used in producing final goods. By incorporating the factor of staggered price-setting mainly into the deterministic version of the model of Huang and Liu (2006), Huang and Liu (2007) examine business cycles driven by monetary shocks. They find that incorporating staggered price-setting makes their model an improvement over the standard NOEM model. Dohwa (2014) examines the effects of a home monetary shock on the welfare of both countries using the two-country model with two stages of production and trade, taking into account firms' asymmetric price-setting behavior. He shows that a home monetary shock has (i) a beggar-thyself effect if the ratio of foreign intermediate goods firms that set their export prices in the local currency is significantly low and (ii) a prosper-thy-neighbor effect in his model regardless of the ratio of either country's intermediate goods firms that set their export prices in the local currency.

[1] Feenstra (1998) and Yi (2003) also emphasize this point in their papers.

[2] In this paper, we basically regard a simple two-country version of deterministic NOEM models including the model of Obstfeld and Rogoff (1995) as the standard NOEM model.

On the other hand, many recent open macroeconomic researches that include researches based on the NOEM model have also examined the role of firm entry in the international business cycle, and the international transmission effects of various policies and productivity shocks. For example, using the standard NOEM model with nominal wage and price rigidities, Corsetti et al. (2004) examine the role of firm entry in the domestic and international transmission effects of a home monetary shock, and real shocks to both home entry costs and aggregate labor productivity in the home manufacturing sector. Ghironi and Melitz (2005) construct a two-country, flexible-price model with heterogeneity in the productivity of firms, and examine the effects of real shocks to both home entry costs and aggregate labor productivity in the home manufacturing sector. As shown in Corsetti et al. (2004), they show that these shocks influence the degree of endogenous entry of firms. Utilizing the basic structure of Ghironi and Melitz (2005), Corsetti et al. (2007) also examine the domestic and international transmission effects of various home real shocks and home government spending shocks on firm entry and exit, and welfare. By incorporating the factor of foreign direct investment (FDI) into the stochastic two-country NOEM model, Russ (2007) examines the relationship between the fluctuation of the nominal exchange rate and the multinational enterprise's decision to enter a market.[3] He shows that the source of such a fluctuation determines whether or not firms encourage FDI. Cavallari (2013) examines the problem of international business cycles using a two-country dynamic stochastic general equilibrium model. By assuming that prior to entry, investors must acquire a composite of domestic and foreign goods, he finds that the formation of new firms can generate fluctuations in output, employment, investment and trade flows close to those in the data.

In this paper, we incorporate the factor of vertical production and trade into the model of Corsetti et al. (2004). In addition, we also incorporate the factor of asymmetric price-setting behavior of home and foreign intermediate goods firms into the model of Corsetti et al. (2004). The reason why we incorporate the second factor is because many researchers find that many firms in major developed countries other than the U.S. set their export prices in

[3]Using the two-country model with flexible price, Johdo and Hashimoto (2005) also examine the issue of firm entry and exit between the two countries. More precisely, they examine the effect of a rise in the corporate tax rate of the home country on the spatial distribution of firms between the two countries.

the local currency.[4] Then, we examine the effect of asymmetric price-setting behavior on the domestic and international transmission effects of a home monetary shock and two types of home productivity shocks, namely, a productivity shock in the home final goods sector, and a productivity shock in the sector at the origin of the creation of the new final goods in the home country.[5] The formulation of a two-country model with the three factors of asymmetry in price-setting behavior between home and foreign intermediate goods firms, vertical production and trade, and endogenous entry of home and foreign final goods firms enables the resolution of issues that cannot be handled by models that are more conventional. These issues include the relationship between the asymmetric price-setting behavior of home and foreign intermediate goods firms and the number of home and foreign final goods firms, and the role played by the asymmetric price-setting behavior of home and foreign intermediate goods firms, which affects the macroeconomic variables and welfare based on the above relationship.

The main results of this paper are as follows. First, we show that a rise in the ratio of home and/or foreign intermediate goods firms that set their export prices in the local currency magnifies the degree of the response of the nominal exchange rate caused by each of three types of shocks originating in the home country. To be more precise, a rise in the ratio of such home and/or foreign intermediate goods firms weakens the depreciation of the nominal exchange rate caused by a home monetary shock and the appreciation of the nominal exchange rate caused by each of the two types of home productivity shocks. These results are basically different from those obtained from the standard NOEM model. Second, we show that each of the three types of shocks has an effect on firm entry and exit. For example, although a home

[4]Examples include Marston (1990), Knetter (1993), Parsley (1993), Athukorala and Menon (1994), ECU Institute (1995) and Gagnon and Knetter (1995).

[5]Betts and Devereux (2000), and Michaelis (2006) also perform almost the same analysis as this paper. By incorporating firms' symmetric price-setting behavior into the two-country model proposed by Obstfeld and Rogoff (1995), Betts and Devereux (2000) examine the effect of symmetric price-setting behavior on the domestic and international transmission effects of a home monetary shock. However, they examine such an effect using a model without the two factors of vertical trading chain and firm entry. By incorporating firms' asymmetric price-setting behavior into the two-country model proposed by Corsetti and Pesenti (2001), Michaelis (2006) examines the effect of asymmetric price-setting behavior on the domestic and international transmission effects of a home monetary shock. However, he also examines such an effect using a model without the two factors of vertical trading chain and firm entry.

monetary shock encourages the entry of new home final goods firms, it also has the potential to encourage the entry of new foreign final goods firms. On the other hand, a productivity shock in the sector at the origin of the creation of the new final goods in the home country discourages the entry of new foreign final goods firms. In addition, we show that these effects depend on the ratio of home and/or foreign intermediate goods firms that set their export prices in the local currency. Third, we show that when the ratio of home and/or foreign intermediate goods firms that set their export prices in the local currency rises, a home monetary shock has a beggar-thy-neighbor effect in the sense that it causes foreign welfare to deteriorate. This effect is obtained based on the result that a home monetary shock causes the negative effect on welfare from employment to dominate the positive effect on welfare from the consumption of final goods. On the other hand, we show that when the ratios of both countries' intermediate goods firms that set their export prices in the local currency are zero, a home monetary shock has no effect on home welfare. This effect is obtained based on the result that a home monetary shock produces a positive effect on welfare from the consumption of final goods and a negative effect on welfare from employment equally. Finally, we show that the two types of home productivity shocks raise home welfare regardless of the ratio of the home and/or foreign intermediate goods firms that set their export prices in the local currency. In addition, in scenarios other than the scenario where the ratios of both countries' intermediate goods firms that set their export prices in the local currency are unity, we show that a productivity shock in the home final goods sector causes foreign welfare to deteriorate. Further, we show that a productivity shock in the sector at the origin of the creation of the new final goods in the home country causes foreign welfare to deteriorate regardless of the ratio of such home and/or foreign intermediate goods firms. The above effects of the two types of home productivity shocks on foreign welfare are also obtained based on the result that each of such shocks causes the negative effect on welfare from employment to dominate the positive effect on welfare from the consumption of final goods.

The remainder of this paper is structured as follows. Section 2 presents the model. Section 3 discusses the transmission mechanism of a home monetary shock and the two types of home productivity shocks on the macroeconomic variables of both countries. Section 4 discusses the effects of a home monetary shock and the two types of home productivity shocks on the welfare of both countries. Section 5 summarizes the findings of this paper.

2 The model

2.1 Definitions of various prices

The world consists of two countries, one denoted as the home country and the other as the foreign country. We denote the foreign variables with an asterisk. Both countries have the same population size, which is normalized to unity: Home households are defined over a continuum of unit mass and indexed by $x \in [0,1]$, foreign households by $x^* \in [0,1]$. Households are immobile across countries. They consume a composite of differentiated final goods produced in the home and foreign countries. Our assumption about the vertical trade is based on that in Shi and Xu (2007),[6] and Dohwa (2014). There are two types of firms in each country: final goods firms and intermediate goods firms, and both kinds of goods are tradable. Firms of the first type produce differentiated final goods using a composite of domestically produced intermediate inputs and a composite of imported intermediate inputs, while those of the second type produce differentiated products using labor. Both final goods firms and intermediate goods firms are monopolistically competitive producers. We assume that the final goods firms operating in the home country in period t continuously exist in the interval $[0, n_t]$ and that those operating in the foreign country in period t continuously exist in the interval $[0, n_t^*]$, where n_t and n_t^* are endogenous.[7] There is free entry in the final goods sector, but final goods firms face fixed entry costs to start production of a particular good.[8] The home and foreign intermediate goods are the inputs required for the formulation of entry costs.[9] On the other hand, although we assume that the number of intermediate goods firms in both countries are normalized to unity,[10] we assume that a fraction s of the

[6]Shi and Xu (2007) examine the issue of non-cooperative optimal monetary policy in a world with vertical production and trade by incorporating two stages of production and trade into the stochastic two-country NOEM model.

[7]The final goods firms operating in the home country are indexed by $z_F \in [0, n_t]$. Similarly, the foreign final goods firms are indexed by $z_F^* \in [0, n_t^*]$.

[8]As defined above, although $[0, n_t]$ and $[0, n_t^*]$ represent intervals for final goods firms, they can be also interpreted as intervals for home and foreign final goods.

[9]We assume that both a composite of the inputs produced by home intermediate goods firms and a composite of the inputs produced by foreign intermediate goods firms are required as inventory in setting up a final goods firm.

[10]The home and foreign intermediate goods firms are indexed by $z_I \in [0,1]$ and $z_I^* \in [0,1]$, respectively.

intermediate goods firms located in the home country and a fraction s^* of the intermediate goods firms located in the foreign country set their export prices in the local currency, i.e., they employ local-currency-pricing (LCP). The remaining intermediate goods firms located in both countries set their export prices in their own currency, i.e., they employ producer-currency-pricing (PCP). This paper adopts a consumption index of the Dixit and Stigliz (1977) type as the aggregate consumption index (shown below), in which case the consumption-based price indexes (CPIs) are given by:

$$P_t = \left(\int_0^{n_t} p_{h,t}(z_F)^{1-\lambda} dz_F + \int_0^{n_t^*} p_{f,t}(z_F^*)^{1-\lambda} dz_F^* \right)^{\frac{1}{1-\lambda}}, \tag{1}$$

$$P_t^* = \left(\int_0^{n_t} p_{h,t}^*(z_F)^{1-\lambda} dz_F + \int_0^{n_t^*} p_{f,t}^*(z_F^*)^{1-\lambda} dz_F^* \right)^{\frac{1}{1-\lambda}}, \tag{2}$$

where P_t (P_t^*) is the CPI of the home (foreign) country, $p_{h,t}(z_F)$ ($p_{f,t}(z_F^*)$) is the home-currency price of the goods produced by home (foreign) final goods firm z_F (z_F^*), $p_{h,t}^*(z_F)$ ($p_{f,t}^*(z_F^*)$) is the foreign-currency price of the goods produced by home (foreign) final goods firm z_F (z_F^*), and $\lambda > 1$ is the elasticity of substitution between any two differentiated final goods. This paper assumes that the law of one price holds for final goods in all the periods. Then, the following relationships are derived:

$$p_{h,t}(z_F) = \varepsilon_t p_{h,t}^*(z_F), \tag{3}$$

$$p_{f,t}(z_F^*) = \varepsilon_t p_{f,t}^*(z_F^*), \tag{4}$$

where ε_t is the nominal exchange rate, defined as the home-currency price of the foreign currency. From Eqs.(1), (2), (3) and (4), purchasing power parity (PPP) holds true:

$$P_t = \varepsilon_t P_t^*. \tag{5}$$

In addition, Eq.(5) implies that the CPI-based real exchange rate is unity:

$$\frac{\varepsilon_t P_t^*}{P_t} = 1. \tag{6}$$

With regard to the production of final goods, this paper adopts a production function of the Cobb-Douglas type (shown below), in which case the unit costs to produce final goods are given by:

$$\Lambda_t = \frac{\tilde{P}_{h,t}^{\frac{1}{2}} \tilde{P}_{f,t}^{\frac{1}{2}}}{\theta_t}, \tag{7}$$

$$\Lambda_t^* = \frac{\tilde{P}_{h,t}^{*\frac{1}{2}} \tilde{P}_{f,t}^{*\frac{1}{2}}}{\theta_t^*}, \tag{8}$$

where

$$\tilde{P}_{f,t} = \left(s^* \left(\tilde{P}_{f,t}^{LCP} \right)^{1-\sigma} + (1-s^*) \left(\tilde{P}_{f,t}^{PCP} \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}, \tag{9}$$

$$\tilde{P}_{h,t}^* = \left(s \left(\tilde{P}_{h,t}^{*LCP} \right)^{1-\sigma} + (1-s) \left(\tilde{P}_{h,t}^{*PCP} \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}, \tag{10}$$

and

$$\tilde{P}_{h,t} = \left(\int_0^1 \tilde{p}_{h,t}(z_I)^{1-\sigma} dz_I \right)^{\frac{1}{1-\sigma}}, \; \tilde{P}_{f,t}^* = \left(\int_0^1 \tilde{p}_{f,t}^*(z_I^*)^{1-\sigma} dz_I^* \right)^{\frac{1}{1-\sigma}}, \tag{11}$$

$$\tilde{P}_{f,t}^{LCP} = \left(\frac{1}{s^*} \int_0^{s^*} \tilde{p}_{f,t}^{LCP}(z_I^*)^{1-\sigma} dz_I^* \right)^{\frac{1}{1-\sigma}}, \; \tilde{P}_{h,t}^{*LCP} = \left(\frac{1}{s} \int_0^{s} \tilde{p}_{h,t}^{*LCP}(z_I)^{1-\sigma} dz_I \right)^{\frac{1}{1-\sigma}}, \tag{12}$$

$$\tilde{P}_{f,t}^{PCP} = \left(\frac{1}{1-s^*} \int_{s^*}^1 \tilde{p}_{f,t}^{PCP}(z_I^*)^{1-\sigma} dz_I^* \right)^{\frac{1}{1-\sigma}}, \; \tilde{P}_{h,t}^{*PCP} = \left(\frac{1}{1-s} \int_{s}^1 \tilde{p}_{h,t}^{*PCP}(z_I)^{1-\sigma} dz_I \right)^{\frac{1}{1-\sigma}}. \tag{13}$$

In Eqs.(7) and (8), $\tilde{P}_{h,t}$ ($\tilde{P}_{h,t}^*$) is the home (foreign)-currency price that corresponds to a composite of the inputs produced by home intermediate goods firms, $\tilde{P}_{f,t}$ ($\tilde{P}_{f,t}^*$) is the home (foreign)-currency price that corresponds to a composite of the inputs produced by foreign intermediate goods firms and θ_t (θ_t^*) is the final goods sector-specific productivity shock in the home (foreign) country. The import price indexes of home and foreign final goods firms are given in Eqs.(9) and (10), where $\tilde{P}_{f,t}^{PCP}$ ($\tilde{P}_{f,t}^{LCP}$) is the home-currency price that corresponds to a composite of the inputs produced by foreign PCP (LCP) intermediate goods firms, and $\tilde{P}_{h,t}^{*PCP}$ ($\tilde{P}_{h,t}^{*LCP}$) is the foreign-currency price that corresponds to a composite of the inputs produced by home PCP (LCP) intermediate goods firms. In Eqs.(11), (12) and (13), $\tilde{p}_{h,t}(z_I)$ ($\tilde{p}_{f,t}^*(z_I^*)$) is the home (foreign)-currency price of the input produced by home (foreign) intermediate goods firm z_I (z_I^*), $\tilde{p}_{f,t}^{PCP}(z_I^*)$ ($\tilde{p}_{f,t}^{LCP}(z_I^*)$) is the home-currency price of the input produced by foreign PCP (LCP) intermediate goods firm z_I^*, $\tilde{p}_{h,t}^{*PCP}(z_I)$ ($\tilde{p}_{h,t}^{*LCP}(z_I)$) is the foreign-currency price of the input produced by home PCP (LCP) intermediate goods firm z_I, and $\sigma > 1$ is the elasticity of substitution between any two differentiated inputs.

2.2 Firms

2.2.1 Final goods firms

Each of the home final goods firms uses home and foreign intermediate goods to produce output according to the following production function:

$$Y_t(z_F) = 2\theta_t Y_{h,t}(z_F)^{\frac{1}{2}} Y_{f,t}(z_F)^{\frac{1}{2}}, \tag{14}$$

where

$$Y_{h,t}(z_F) = \left(\int_0^1 Y_{h,t}(z_F, z_I)^{\frac{\sigma-1}{\sigma}} dz_I \right)^{\frac{\sigma}{\sigma-1}}, \tag{15}$$

$$Y_{f,t}(z_F) = \left(\int_0^{s^*} Y_{f,t}^{LCP}(z_F, z_I^*)^{\frac{\sigma-1}{\sigma}} dz_I^* + \int_{s^*}^1 Y_{f,t}^{PCP}(z_F, z_I^*)^{\frac{\sigma-1}{\sigma}} dz_I^* \right)^{\frac{\sigma}{\sigma-1}}. \tag{16}$$

In Eq.(14), $Y_t(z_F)$ is the output produced by home final goods firm z_F and $Y_{h,t}(z_F)$ ($Y_{f,t}(z_F)$) is a composite of the home (foreign) intermediate inputs used by home final goods firm z_F. $Y_{h,t}(z_F)$ and $Y_{f,t}(z_F)$ are given in Eqs.(15) and (16), where $Y_{h,t}(z_F, z_I)$ is the home intermediate input z_I used by home final goods firm z_F, and $Y_{f,t}^{PCP}(z_F, z_I^*)$ ($Y_{f,t}^{LCP}(z_F, z_I^*)$) is the foreign PCP (LCP) intermediate input z_I^* used by home final goods firm z_F. Here, the home final goods firm z_F's expenditure for the sum of $Y_{h,t}(z_F)$ and $Y_{f,t}(z_F)$ is represented as follows:

$$\Lambda_t Y_t(z_F) = \tilde{P}_{h,t} Y_{h,t}(z_F) + \tilde{P}_{f,t} Y_{f,t}(z_F). \tag{17}$$

Subject to Eq.(14), the home final goods firm z_F minimizes Eq.(17). Then, the demands of the home final goods firm z_F for $Y_{h,t}(z_F)$ and $Y_{f,t}(z_F)$ are derived as follows:

$$Y_{h,t}(z_F) = \frac{1}{2} \left(\frac{\tilde{P}_{h,t}}{\Lambda_t} \right)^{-1} Y_t(z_F), \tag{18}$$

$$Y_{f,t}(z_F) = \frac{1}{2} \left(\frac{\tilde{P}_{f,t}}{\Lambda_t} \right)^{-1} Y_t(z_F). \tag{19}$$

Next, we consider the home final goods firm z_F's demand for input produced by home intermediate goods firm z_I. Here, a composite of the inputs produced by home intermediate goods firms is given by Eq.(15), and the home final goods firm z_F's nominal expenditure for the inputs produced by home intermediate goods firms is formulated as $\tilde{P}_{h,t} Y_{h,t}(z_F) =$

$\int_0^1 \tilde{p}_{h,t}(z_I)Y_{h,t}(z_F, z_I)dz_I$. Subject to Eq.(15), the home final goods firm z_F determines $Y_{h,t}(z_F, z_I)$ in order to minimize this expenditure. Then, the home final goods firm z_F's demand for the input produced by home intermediate goods firm z_I is derived as follows:

$$Y_{h,t}(z_F, z_I) = \left(\frac{\tilde{p}_{h,t}(z_I)}{\tilde{P}_{h,t}}\right)^{-\sigma} Y_{h,t}(z_F). \tag{20}$$

Similarly, the home final goods firm z_F's demands for the inputs produced by foreign PCP intermediate goods firm z_I^* and foreign LCP intermediate goods firm z_I^* can be calculated as follows:

$$Y_{f,t}^{PCP}(z_F, z_I^*) = \left(\frac{\tilde{p}_{f,t}^{PCP}(z_I^*)}{\tilde{P}_{f,t}^{PCP}}\right)^{-\sigma} \left(\frac{\tilde{P}_{f,t}^{PCP}}{\tilde{P}_{f,t}}\right)^{-\sigma} Y_{f,t}(z_F), \tag{21}$$

$$Y_{f,t}^{LCP}(z_F, z_I^*) = \left(\frac{\tilde{p}_{f,t}^{LCP}(z_I^*)}{\tilde{P}_{f,t}^{LCP}}\right)^{-\sigma} \left(\frac{\tilde{P}_{f,t}^{LCP}}{\tilde{P}_{f,t}}\right)^{-\sigma} Y_{f,t}(z_F). \tag{22}$$

Combining Eqs.(18) and (20), the home final goods firm z_F's demand for the input produced by home intermediate goods firm z_I is derived in the following exact form:

$$Y_{h,t}(z_F, z_I) = \frac{1}{2}\left(\frac{\tilde{p}_{h,t}(z_I)}{\tilde{P}_{h,t}}\right)^{-\sigma} \left(\frac{\tilde{P}_{h,t}}{\Lambda_t}\right)^{-1} Y_t(z_F). \tag{23}$$

Similarly, the home final goods firm z_F's demands for the inputs produced by foreign PCP intermediate goods firm z_I^* and foreign LCP intermediate goods firm z_I^* are derived in the exact form as follows:

$$Y_{f,t}^{PCP}(z_F, z_I^*) = \frac{1}{2}\left(\frac{\tilde{p}_{f,t}^{PCP}(z_I^*)}{\tilde{P}_{f,t}^{PCP}}\right)^{-\sigma} \left(\frac{\tilde{P}_{f,t}^{PCP}}{\tilde{P}_{f,t}}\right)^{-\sigma} \left(\frac{\tilde{P}_{f,t}}{\Lambda_t}\right)^{-1} Y_t(z_F), \tag{24}$$

$$Y_{f,t}^{LCP}(z_F, z_I^*) = \frac{1}{2}\left(\frac{\tilde{p}_{f,t}^{LCP}(z_I^*)}{\tilde{P}_{f,t}^{LCP}}\right)^{-\sigma} \left(\frac{\tilde{P}_{f,t}^{LCP}}{\tilde{P}_{f,t}}\right)^{-\sigma} \left(\frac{\tilde{P}_{f,t}}{\Lambda_t}\right)^{-1} Y_t(z_F). \tag{25}$$

Here, the resource constraint for goods produced by the home final goods firm z_F is represented as follows:

$$Y_t(z_F) \geq \int_0^1 C_{h,t}(z_F, x)dx + \int_0^1 C_{h,t}^*(z_F, x^*)dx^*, \tag{26}$$

where $C_{h,t}(z_F, x)$ is the home household x's consumption of goods produced by the home final goods firm z_F and $C^*_{h,t}(z_F, x^*)$ is the foreign household x^*'s consumption of goods produced by the home final goods firm z_F. Using Eq.(26), the home final goods firm z_F's profit is represented as follows:

$$\Pi_{F,t}(z_F) = p_{h,t}(z_F) \int_0^1 C_{h,t}(z_F, x)dx + \varepsilon_t p^*_{h,t}(z_F) \int_0^1 C^*_{h,t}(z_F, x^*)dx^* - \Lambda_t Y_t(z_F). \tag{27}$$

To start production, each of the final goods firms must pay a fixed cost. We assume that the cost of creating a new home final good is represented as follows:[11]

$$q_t(z_F) = \frac{(n_t + \delta n^*_t)^\gamma \left(\tilde{P}_{h,t} + \tilde{P}_{f,t}\right)}{\nu_t}, \quad \gamma \geq 0, \quad 0 \leq \delta \leq 1, \tag{28}$$

where ν_t is a productivity shock in the sector at the origin of the creation of the new final goods in the home country. Eq.(28) shows that it takes both $(n_t + \delta n^*_t)^\gamma / \nu_t$ units of the composite of home intermediate inputs and $(n_t + \delta n^*_t)^\gamma / \nu_t$ units of that of foreign intermediate inputs to create a new final good in the home country. Given this equation, the resource constraints in home and foreign intermediate inputs used by home final goods firms are represented as follows:

$$Y_{h,t} \geq \frac{1}{2}\left(\frac{\tilde{P}_{h,t}}{\Lambda_t}\right)^{-1} Y_t + \frac{n_t(n_t + \delta n^*_t)^\gamma}{\nu_t}, \tag{29}$$

$$Y_{f,t} \geq \frac{1}{2}\left(\frac{\tilde{P}_{f,t}}{\Lambda_t}\right)^{-1} Y_t + \frac{n_t(n_t + \delta n^*_t)^\gamma}{\nu_t}. \tag{30}$$

2.2.2 Intermediate goods firms

As shown in more detail below, the home PCP intermediate goods firm z_I and LCP intermediate goods firm z_I both produce a differentiated good using

[11] With regard to the foreign country, we assume that the cost of creating a new final good, expressed in home currency, is:
$\varepsilon_t q^*_t(z^*_F) = \frac{\varepsilon_t(\delta n_t + n^*_t)\left(\tilde{P}^*_{h,t} + \tilde{P}^*_{f,t}\right)}{\nu^*_t}$.

a continuum of labor inputs provided by the home households, respectively:

$$Y_{h,t}^{PCP}(z_I) + Y_{h,t}^{*PCP}(z_I) = \left(\int_0^1 \ell_t(z_I, x)^{\frac{\xi-1}{\xi}} dx \right)^{\frac{\xi}{\xi-1}}, \tag{31}$$

$$Y_{h,t}^{LCP}(z_I) + Y_{h,t}^{*LCP}(z_I) = \left(\int_0^1 \ell_t(z_I, x)^{\frac{\xi-1}{\xi}} dx \right)^{\frac{\xi}{\xi-1}}, \tag{32}$$

where $Y_{h,t}^{PCP}(z_I)$ ($Y_{h,t}^{LCP}(z_I)$) is the output of goods produced by home PCP (LCP) intermediate goods firm z_I toward home final goods firms, $Y_{h,t}^{*PCP}(z_I)$ ($Y_{h,t}^{*LCP}(z_I)$) is the output of goods produced by home PCP (LCP) intermediate goods firm z_I toward foreign final goods firms, $\ell_t(z_I, x)$ is labor of home household x employed in the production of their goods and $\xi > 1$ is the elasticity of substitution among labor varieties. First, the profit of a home PCP intermediate goods firm z_I is represented as follows:

$$\Pi_{I,t}^{PCP}(z_I) = \tilde{p}_{h,t}(z_I)(Y_{h,t}^{PCP}(z_I) + Y_{h,t}^{*PCP}(z_I)) - W_t(Y_{h,t}^{PCP}(z_I) + Y_{h,t}^{*PCP}(z_I)), \tag{33}$$

where W_t is the aggregate wage index (shown below). Assuming that nominal wages are flexible, given the demand function expressed in Eq.(20), the optimal price is determined as follows:

$$\tilde{p}_{h,t}(z_I) = \frac{\sigma}{\sigma - 1} W_t \equiv \tilde{p}_{h,t}. \tag{34}$$

Eq.(34) shows that the home intermediate goods firm z_I sets its good's price at the marginal cost (W_t) multiplied by the mark-up ratio ($\sigma/(\sigma-1)$). Here, note that the export price of PCP intermediate goods firm z_I is $\tilde{p}_{h,t}(z_I)/\varepsilon_t$.

Next, the profit of a home LCP intermediate goods firm z_I is represented as follows:

$$\Pi_{I,t}^{LCP}(z_I) = \tilde{p}_{h,t}(z_I) Y_{h,t}^{LCP}(z_I) + \varepsilon_t \tilde{p}_{h,t}^{*LCP}(z_I) Y_{h,t}^{*LCP}(z_I) - W_t(Y_{h,t}^{LCP}(z_I) + Y_{h,t}^{*LCP}(z_I)). \tag{35}$$

As per the process of analysis adopted for the profit-maximization problem of a home PCP intermediate goods firm z_I, the sales price of this LCP intermediate goods firm z_I can be expressed in the following equation, when nominal wages are flexible:

$$\tilde{p}_{h,t}(z_I) = \varepsilon_t \tilde{p}_{h,t}^{*LCP}(z_I) = \frac{\sigma}{\sigma - 1} W_t \equiv \tilde{p}_{h,t}. \tag{36}$$

Eqs.(34) and (36) show that the sales price of the PCP intermediate goods firm z_I is equal to that of the LCP intermediate goods firm z_I. Therefore, even if intermediate goods firms set their export prices in different currencies, the law of one price holds for every intermediate good under flexible wages.

On the other hand, as we mention in Section 3, our model takes into account nominal wage rigidity in the short run. Under sticky wages, the law of one price does not hold for the inputs produced by LCP intermediate goods firms. This is because LCP intermediate goods firms do not pass on the exchange rate changes to export prices denominated in the local currency. Focusing on a symmetric equilibrium, as shown in Corsetti and Pesenti (2005), the export prices of the intermediate goods firms of both countries, taking into account the incomplete pass through of the nominal exchange rate, are as follows:

$$\tilde{p}^*_{h,t} = \frac{\hat{\tilde{p}}_{h,t}}{\varepsilon_t^{1-s}}, \tag{37}$$

$$\tilde{p}_{f,t} = \varepsilon_t^{1-s^*} \hat{\tilde{p}}^*_{f,t}, \tag{38}$$

where $\hat{\tilde{p}}_{h,t}$ $\left(\hat{\tilde{p}}^*_{f,t}\right)$ is the predetermined component of the foreign (home)-currency price of input produced by each of home (foreign) intermediate goods firms.

2.3 Households and government

We define the utility function for the home household x as follows:

$$U_t(x) \equiv \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left(\frac{C_\tau^{1-\frac{1}{\psi}}(x)}{1-\frac{1}{\psi}} + \chi ln \frac{M_\tau(x)}{P_\tau} - \kappa \ell_\tau(x) \right), \tag{39}$$

where $\beta \in (0,1)$ is the subjective discount factor, $\psi > 0$ is the elasticity of intertemporal substitution in consumption, $C_t(x)$ is the aggregate consumption index of the home household x, $M_t(x)$ is the home household x's holdings of the home country's currency, $\ell_t(x)$ is the home household x's labor service, and the other Greek letters are positive parameters. This utility function implies that the home household x gains utility by consuming final goods and holding real money, and suffers disutility by supplying labor. As we mentioned before, the aggregate consumption index of home household x is given by:

$$C_t(x) = \left(\int_0^{n_t} C_{h,t}(z_F, x)^{\frac{\lambda-1}{\lambda}} dz_F + \int_0^{n_t^*} C_{f,t}(z_F^*, x)^{\frac{\lambda-1}{\lambda}} dz_F^* \right)^{\frac{\lambda}{\lambda-1}}, \quad (40)$$

where $C_{h,t}(z_F, x)$ is the consumption of the home final good z_F by home household x, and $C_{f,t}(z_F^*, x)$ is the consumption of the foreign final good z_F^* by home household x.

The home household x maximizes utility subject to the following budget constraint:

$$\frac{\varepsilon_t B_{t+1}(x)}{P_t} + \frac{M_t(x)}{P_t} + C_t(x) + \frac{I_t(x)}{P_t} = \frac{\varepsilon_t(1+i_t^*)B_t(x)}{P_t}$$

$$+\frac{M_{t-1}(x)}{P_t} + \frac{w_t(x)\ell_t(x)}{P_t} + \frac{T_t(x)}{P_t} + \frac{\Pi_{F,t}(x)}{P_t} + \frac{\Pi_{I,t}(x)}{P_t}, \quad (41)$$

where $B_t(x)$ is the stock of foreign currency denominated bonds that the home household x holds at the beginning of period t, $I_t(x)$ is the home household x's 'investment' in final goods firms (financing entry costs), i_t^* is the nominal interest rate between periods $t-1$ and t evaluated in foreign currency terms, $w_t(x)$ is the nominal wage, which corresponds to $\ell_t(x)$, $T_t(x)$ are lump-sum transfers from the home government, and $\Pi_{F,t}(x)$ and $\Pi_{I,t}(x)$ are dividend revenues from the final and intermediate goods firms that the home household x owns, respectively.

As mentioned in Corsetti et al. (2004, 2013), we assume that households are endowed with a well-diversified international portfolio of claims on final goods firms' profits, so that they finance the same fraction of the cost of creating new final goods in each country. Then, the investment of the home household x in a diversified portfolio of final goods firms is defined as follows:

$$I_t(x) \equiv \frac{1}{2} \left(\int_0^{n_t} q_t(z_F) dz_F + \varepsilon_t \int_0^{n_t^*} q_t^*(z_F^*) dz_F^* \right). \quad (42)$$

In return, we assume that each of the home households receives an equal share of the profits of all final goods firms in the home and foreign countries:

$$\Pi_{F,t}(x) \equiv \frac{1}{2} \left(\int_0^{n_t} \Pi_{F,t}(z_F) dz_F + \varepsilon_t \int_0^{n_t^*} \Pi_{F,t}^*(z_F^*) dz_F^* \right). \quad (43)$$

In addition, the household is a monopoly supplier of a differentiated labor service and faces the following labor-demand curve:[12]

$$\ell_t(x) = \left(\frac{w_t(x)}{W_t}\right)^{-\xi} \left(\int_0^s Y_{h,t}^{LCP}(z_I) dz_I + \int_s^1 Y_{h,t}^{PCP}(z_I) dz_I \right.$$

$$\left. + \int_0^s Y_{h,t}^{*LCP}(z_I) dz_I + \int_s^1 Y_{h,t}^{*PCP}(z_I) dz_I \right), \tag{44}$$

where $W_t = \left(\int_0^1 w_t(x)^{1-\xi} dx\right)^{\frac{1}{1-\xi}}$ is the constant-elasticity-of-substitution (CES) wage index.

Before turning to the intertemporal maximization problem, we consider the optimal consumption allocation between $C_{h,t}(z_F, x)$ and $C_{f,t}(z_F^*, x)$. Here, the aggregate consumption index is given by Eq.(40), and the nominal consumption expenditure is defined as $P_t C_t(x) \equiv \int_0^{n_t} p_{h,t}(z_F) C_{h,t}(z_F, x) dz_F + \int_0^{n_t^*} p_{f,t}(z_F^*) C_{f,t}(z_F^*, x) dz_F^*$. Subject to the definition of the nominal consumption expenditure, the agent determines $C_{h,t}(z_F, x)$ and $C_{f,t}(z_F^*, x)$ in order to maximize Eq.(40). Then, the optimal consumption allocation between $C_{h,t}(z_F, x)$ and $C_{f,t}(z_F^*, x)$ is derived as follows:

$$C_{h,t}(z_F, x) = \left(\frac{p_{h,t}(z_F)}{P_t}\right)^{-\lambda} C_t(x), \tag{45}$$

$$C_{f,t}(z_F^*, x) = \left(\frac{p_{f,t}(z_F^*)}{P_t}\right)^{-\lambda} C_t(x). \tag{46}$$

Similarly, the optimal consumption allocation between $C_{h,t}^*(z_F, x^*)$ and $C_{f,t}^*(z_F^*, x^*)$ can be calculated as follows:

$$C_{h,t}^*(z_F, x^*) = \left(\frac{p_{h,t}^*(z_F)}{P_t^*}\right)^{-\lambda} C_t^*(x^*), \tag{47}$$

$$C_{f,t}^*(z_F^*, x^*) = \left(\frac{p_{f,t}^*(z_F^*)}{P_t^*}\right)^{-\lambda} C_t^*(x^*). \tag{48}$$

[12] As mentioned in Corsetti et al. (2004), we assume monopolistic competition on the labor market, so that wage setters take the previous expression into account when choosing their wage rates. In addition, we also assume one-period nominal wages contract, so that the wage rate is predetermined in nominal terms.

We now turn to the intertemporal maximization problem. Subject to Eq.(41), the home household x maximizes Eq.(39). Then, the first-order necessary conditions for $C_t(x)$, $M_t(x)$ and $\ell_t(x)$ are derived as follows:

$$\frac{C_{t+1}(x)^{\frac{1}{\psi}}}{C_t(x)^{\frac{1}{\psi}}} = \beta(1+i^*_{t+1})\frac{P_t/\varepsilon_t}{P_{t+1}/\varepsilon_{t+1}}, \tag{49}$$

$$\frac{M_t(x)}{P_t} = \chi\frac{(1+i^*_{t+1})\varepsilon_{t+1}}{(1+i^*_{t+1})\varepsilon_{t+1}-\varepsilon_t}C_t(x)^{\frac{1}{\psi}}, \tag{50}$$

$$\frac{w_t(x)}{P_t} = \frac{\xi\kappa}{\xi-1}C_t(x)^{\frac{1}{\psi}}. \tag{51}$$

Eq.(49) is the Euler equation, Eq.(50) is the real money demand function, and Eq.(51) shows that the real wage rate is equal to a constant markup over the marginal rate of substitution between consumption and leisure.

From now, we denote the first-order necessary conditions for the home households as a whole. For example, we define the average consumption of home households in period t as the integral of $C_t(x)$ over all x. We denote such a variable as C_t. We also define M_t and B_t in analogous ways for money holdings and bond holdings, respectively. Then, by focusing on symmetric equilibrium, where all home households are identical within the home country, we can derive the following relationships for all t:

$$C_t = C_t(x), \quad M_t = M_t(x), \quad B_t = B_t(x). \tag{52}$$

Considering Eqs.(49), (50), (51), (52) and assuming a symmetric equilibrium, the first-order necessary conditions for $C_t(x)$, $M_t(x)$ and $\ell_t(x)$ are corrected as follows, respectively:

$$\frac{C_{t+1}^{\frac{1}{\psi}}}{C_t^{\frac{1}{\psi}}} = \beta(1+i^*_{t+1})\frac{P_t/\varepsilon_t}{P_{t+1}/\varepsilon_{t+1}}, \tag{53}$$

$$\frac{M_t}{P_t} = \chi\frac{(1+i^*_{t+1})\varepsilon_{t+1}}{(1+i^*_{t+1})\varepsilon_{t+1}-\varepsilon_t}C_t^{\frac{1}{\psi}}, \tag{54}$$

$$\frac{W_t}{P_t} = \frac{\xi\kappa}{\xi-1}C_t^{\frac{1}{\psi}}. \tag{55}$$

Under the assumption that revenues from seigniorage are distributed across households in a lump-sum fashion, the budget constraint for the home government can be represented as follows:

$$M_t - M_{t-1} = T_t. \tag{56}$$

To characterize monetary policy, it is convenient to define a variable $\mu_t \equiv P_t C_t^{\frac{1}{\psi}}$.[13] Using this variable, we can rewrite Eqs.(53) and (54) as follows:

$$\frac{1}{\mu_t} = \beta(1 + i^*_{t+1})\frac{\varepsilon_{t+1}}{\varepsilon_t}\frac{1}{\mu_{t+1}} \tag{57}$$

$$M_t = \chi\frac{(1 + i^*_{t+1})\varepsilon_{t+1}}{(1 + i^*_{t+1})\varepsilon_{t+1} - \varepsilon_t}\mu_t \tag{58}$$

As mentioned in Section 3, one of our analytical purposes is to examine the effects of a permanent home monetary shock (μ_t=μ_{t+1}>μ). Eqs.(57) and (58) show that such an expansion yields an increase in the home money stock.

Foreign households have the same preferences as home households. Thus, the foreign household x^*'s lifetime utility function and its budget constraint are shown as follows:

$$U^*_t(x^*) = \sum_{\tau=t}^{\infty}\beta^{\tau-t}\left(\frac{C_\tau^{*1-\frac{1}{\psi}}(x^*)}{1-\frac{1}{\psi}} + \chi ln\frac{M^*_\tau(x^*)}{P^*_\tau} - \kappa\ell^*_\tau(x^*)\right), \tag{59}$$

$$\frac{B^*_{t+1}(x^*)}{P^*_t} + \frac{M^*_t(x^*)}{P^*_t} + C^*_t(x^*) + \frac{I^*_t(x^*)}{P^*_t} = \frac{(1+i^*_t)B^*_t(x^*)}{P^*_t}$$
$$+\frac{M^*_{t-1}(x^*)}{P^*_t} + \frac{w^*_t(x^*)\ell^*_t(x^*)}{P^*_t} + \frac{T^*_t(x^*)}{P^*_t} + \frac{\Pi^*_{F,t}(x^*)}{P^*_t} + \frac{\Pi^*_{I,t}(x^*)}{P^*_t}, \tag{60}$$

where β, χ and κ are the same as in the home country.

Now, we represent the equilibrium condition for the asset market. The worldwide net supply of bonds has to be equal to zero. Therefore, the equilibrium condition for the asset market is represented as follows:[14]

$$B_t + B^*_t = 0. \tag{61}$$

[13]Our definition of the variables of monetary policy is based on that in Corsetti et al. (2004). This definition implies that the government controls an analog of the nominal consumption. In addition, as mentioned in footnotes 15 and 16, we use the relationship of $B_{t+1} = B_t = 0$. Therefore, a temporary home monetary easing at period t, associated with a higher μ_t, leads to a lower i_{t+1} (see Eq.(A) in footnote 14).

[14]We define i_t as the nominal interest rate between periods $t-1$ and t evaluated in home currency terms. Although we do not describe i_t in the text, uncovered interest rate

2.4 Final goods prices and CPIs

From Eqs.(45) and (46), the aggregate home consumption demand for goods produced by the home final goods firm z_F and the foreign final goods firm z_F^* are represented as follows:

$$\int_0^1 C_{h,t}(z_F, x)dx \equiv C_{h,t}(z_F) = \left(\frac{p_{h,t}(z_F)}{P_t}\right)^{-\lambda} C_t, \tag{62}$$

$$\int_0^1 C_{f,t}(z_F^*, x)dx \equiv C_{f,t}(z_F^*) = \left(\frac{p_{f,t}(z_F^*)}{P_t}\right)^{-\lambda} C_t. \tag{63}$$

Substituting Eq.(62) and its foreign analog in Eq.(27), we can easily derive the optimal prices charged by home final goods firm z_F as follows:

$$p_{h,t}(z_F) = \frac{\lambda}{\lambda - 1}\Lambda_t \equiv p_{h,t}, \tag{64}$$

$$\varepsilon_t p_{h,t}^*(z_F) = \frac{\lambda}{\lambda - 1}\Lambda_t \equiv p_{h,t}. \tag{65}$$

Similarly, we can also derive the optimal prices charged by the foreign final goods firm z_F^* as follows:

$$p_{f,t}^*(z_F^*) = \frac{\lambda}{\lambda - 1}\Lambda_t^* \equiv p_{f,t}^*, \tag{66}$$

$$\frac{p_{f,t}(z_F^*)}{\varepsilon_t} = \frac{\lambda}{\lambda - 1}\Lambda_t^* \equiv p_{f,t}^*. \tag{67}$$

Here, using Eqs.(11), (34), (36), (37) and (38), the unit costs to produce home and foreign final goods, which are given in Eqs.(7) and (8), can be represented as follows:

$$\Lambda_t = \frac{\frac{\sigma}{\sigma-1}\varepsilon_t^{\frac{1-s^*}{2}}}{\theta_t} W_t, \tag{68}$$

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parity (UIP), i.e., $1 + i_t = (1 + i_t^*)(\varepsilon_t/\varepsilon_{t-1})$, holds between i_t and i_t^*, since there is free trade between the countries in nominal bonds. From here onwards Eqs.(57) and (58) can be rewritten as follows, respectively:

$$\frac{1}{\mu_t} = \beta(1 + i_{t+1})\frac{1}{\mu_{t+1}}, \tag{A}$$

$$M_t = \chi\frac{1 + i_{t+1}}{i_{t+1}}\mu_t. \tag{B}$$

$$\Lambda_t^* = \frac{\frac{\sigma}{\sigma-1}\varepsilon_t^{\frac{s-1}{2}}}{\theta_t^*} W_t^*. \tag{69}$$

Therefore, from Eqs.(64), (65), (66), (67), (68) and (69), $p_{h,t}$ and $p_{f,t}^*$ can be rewritten as follows:

$$p_{h,t} = \frac{\lambda}{\lambda-1}\frac{\sigma}{\sigma-1}\frac{\varepsilon_t^{\frac{1-s^*}{2}}}{\theta_t} W_t, \tag{70}$$

$$p_{f,t}^* = \frac{\lambda}{\lambda-1}\frac{\sigma}{\sigma-1}\frac{\varepsilon_t^{\frac{s-1}{2}}}{\theta_t^*} W_t^*. \tag{71}$$

With regard to the CPIs of both countries, from Eqs.(64), (65), (66) and (67), they are equal to:

$$P_t = p_{h,t} A_t^{\frac{1}{1-\lambda}}, \tag{72}$$

$$P_t^* = p_{f,t}^* A_t^{*\frac{1}{1-\lambda}}, \tag{73}$$

where

$$A_t \equiv n_t + n_t^*(\varepsilon_t p_{f,t}^*/p_{h,t})^{1-\lambda}, \tag{74}$$

$$A_t^* \equiv n_t^* + n_t(\varepsilon_t p_{f,t}^*/p_{h,t})^{\lambda-1}. \tag{75}$$

2.5 Free entry and the balance of payments

In this subsection, we mainly represent the conditions that held under a situation of free entry and the balance of payments of the home country. To begin with, using Eqs.(26), (27) and (64), we can represent the profits earned by the home final goods firm z_F as follows:

$$\Pi_{F,t}(z_F) = \frac{p_{h,t}^{1-\psi}}{\lambda}\left(\frac{\mu_t^{\psi}}{A_t^{\frac{\lambda-\psi}{\lambda-1}}} + \frac{\left(\frac{\varepsilon_t p_{f,t}^*}{p_{h,t}}\right)^{\lambda-\psi}(\varepsilon_t\mu_t^*)^{\psi}}{A_t^{*\frac{\lambda-\psi}{\lambda-1}}}\right) \equiv \pi_{F,t}. \tag{76}$$

Similarly, we can represent the profits earned by the foreign final goods firm z_F^* as follows:

$$\Pi_{F,t}^*(z_F^*) = \frac{p_{f,t}^{*1-\psi}}{\lambda}\left(\frac{\left(\frac{\mu_t}{\varepsilon_t}\right)^{\psi}\left(\frac{\varepsilon_t p_{f,t}^*}{p_{h,t}}\right)^{\psi-\lambda}}{A_t^{\frac{\lambda-\psi}{\lambda-1}}} + \frac{\mu_t^{*\psi}}{A_t^{*\frac{\lambda-\psi}{\lambda-1}}}\right) \equiv \pi_{F,t}^*. \tag{77}$$

Eqs.(76) and (77) show that the sign of the relationship between profits and the number of home and/or foreign final goods firms depends on whether $\lambda > \psi$ or $\lambda < \psi$. This can be explained as follows. First, when the number of home and/or foreign final goods firms increases, the CPIs in both countries decrease, which causes the increase in current consumptions in both countries. This effect, which implies intertemporal substitution into current consumption, is measured by ψ. On the other hand, there is also the effect of a decrease in the current consumptions of goods produced by existing home and/or foreign final goods firms. This is because they are replaced by the current consumptions of goods produced by new home and/or foreign final goods firms. This effect, which implies intratemporal substitution, is measured by λ. The net effect is given by $\lambda - \psi$. Therefore, since the increase in the number of home and/or foreign final goods firms leads to lower (higher) current consumption of goods produced by existing home and/or foreign final goods firms if $\lambda > \psi$ ($\lambda < \psi$), this causes a decrease (increase) in profits through a decrease (increase) in the sales revenues.

With free entry, optimal investment in new final goods implies that the value of a final goods firm is equal to the cost of creating a final good, and in equilibrium this must be equal to the value of the profits. Therefore, the following relationships are derived:

$$q_t = \frac{(n_t + \delta n_t^*)^\gamma (\tilde{p}_{h,t} + \tilde{p}_{f,t})}{\nu_t} = \pi_{F,t}, \tag{78}$$

$$q_t^* = \frac{(\delta n_t + n_t^*)^\gamma (\tilde{p}_{h,t}^* + \tilde{p}_{f,t}^*)}{\nu_t^*} = \pi_{F,t}^*. \tag{79}$$

We define these relationships as the free entry conditions. Here, note that in the special case of $\psi = 1$, equating total world sales to total world expenditure, we can also represent the following relationship:

$$\lambda n_t \pi_{F,t} + \lambda n_t^* \varepsilon_t \pi_{F,t}^* = \mu_t + \varepsilon_t \mu_t^*. \tag{80}$$

Next, aggregating the households' budget constraints in the home country, and using the government budget constraint and the relationship of $B_{t+1} = B_t = 0$, we can represent the balance of payments of the home country as follows:[15]

$$\left(\frac{n_t(\varepsilon_t \mu_t^*)^{\psi} p_{h,t}^{1-\psi} \left(\frac{\varepsilon_t p_{f,t}^*}{p_{h,t}}\right)^{\lambda-\psi}}{A_t^{*\frac{\lambda-\psi}{\lambda-1}}} - \frac{n_t^* p_{f,t}^{*1-\psi} \mu_t^{\psi} \varepsilon_t^{1-\lambda} \left(\frac{p_{f,t}^*}{p_{h,t}}\right)^{\psi-\lambda}}{A_t^{\frac{\lambda-\psi}{\lambda-1}}} \right)$$

$$-\frac{\pi_{F,t} n_t}{2} + \frac{\varepsilon_t \pi_{F,t}^* n_t^*}{2} + \frac{q_t n_t}{2} - \frac{\varepsilon_t q_t^* n_t^*}{2} = 0. \quad (81)$$

On the left-hand side of Eq.(81), the first term represents home exports, while the second term represents home imports. Therefore, their difference is the trade balance. The third term represents net profits paid by home final goods firms to foreign households, and the fourth term represents net profits paid by foreign final goods firms to home households. Therefore, their difference is the net factor payments. The sum of the trade balance and the net factor payments constitutes the current account. The sum of the last two terms represents the financial account, i.e., the financing of home final goods firms by foreign households minus the financing of foreign final goods firms by home households.

3 The transmission mechanism in an economy without trade in international bonds

In this section, we examine the effects of an unanticipated permanent shock to the home monetary stance μ_t, and unanticipated temporary shocks to the home productivities θ_t and ν_t.[16] We distinguish between three periods. In the initial period, the economy is in a symmetric steady state where no country has any net claims on the other. In period t, the above shocks occur and we observe a short-run equilibrium, which assumes that nominal wages are fixed, before the shocks can be observed. In the long run (from period $t+1$ onward), nominal wages are adjusted, and all variables reach their new steady-state values. To represent variables in the initial steady-state, we hereafter represent these variables without a time subscript. Although we distinguish between three periods, all real variables in the long run return

[15] With regard to the relationship of $B_{t+1} = B_t = 0$, refer to the content in footnote 16.

[16] In this paper, we focus on the analytical investigation as much as possible. Therefore, we examine the effects of three types of shocks by ruling out trade in international bonds.

to their pre-shock levels, since we assume the absence of current account imbalances. Therefore, we examine only the short-run effects of these shocks.

3.1 The initial steady state

In this subsection, we illustrate closed form solutions derived in the initial steady state with $B = B^* = 0$ and $\mu = \mu^* = \theta = \theta^* = \nu = \nu^* = 1$.[17]

To begin with, from Eq.(55) and its foreign analog, we derive:

$$W = W^* = \frac{\xi\kappa}{\xi - 1}. \tag{82}$$

Next, from Eq.(5) and the two conditions of $PC^{\frac{1}{\psi}} = P^* C^{*\frac{1}{\psi}}$ and $C = C^*$, we derive:

$$\varepsilon = 1. \tag{83}$$

Further, from Eqs.(82) and (83), and the relationships of $\tilde{p}_h^* = \tilde{p}_h/\varepsilon$, $\tilde{p}_f = \varepsilon\tilde{p}_f^*$, $\tilde{p}_h = \frac{\sigma}{\sigma-1}W$ and $\tilde{p}_f^* = \frac{\sigma}{\sigma-1}W^*$, we derive:

$$\tilde{p}_h = \tilde{p}_h^* = \tilde{p}_f = \tilde{p}_f^* = \frac{\sigma}{\sigma - 1}\frac{\xi\kappa}{\xi - 1}. \tag{84}$$

From Eqs.(78), (79), (81), (83) and (84), we obtain the relationship between the number of home final goods firms and that of foreign final goods firms as follows:

$$n = n^*. \tag{85}$$

Moreover, from Eqs.(70), (71), (82) and (83), we derive:

$$p_h = p_h^* = p_f = p_f^* = \frac{\lambda}{\lambda - 1}\frac{\sigma}{\sigma - 1}\frac{\xi\kappa}{\xi - 1}. \tag{86}$$

Here, from Eqs.(74), (75), (76), (78), (83), (85) and (86), the relationship between the number of home final goods firms and that of foreign final goods firms is shown as follows:

$$n = n^* = 2^{\frac{\psi-1}{\lambda-\psi}}[q\lambda p_h^{\psi-1}]^{\frac{1-\lambda}{\lambda-\psi}}. \tag{87}$$

Finally, from Eqs.(18), (19), (44), (78), (79), $\pi_F = \frac{p_h Y(z_F)}{\lambda}$ and their foreign analogs, the home and foreign labor services are derived as follows:

$$\ell = \ell^* = 2\lambda n^{1+\gamma}(1+\delta)^{\gamma}. \tag{88}$$

[17]We assume that the initial steady-state levels of home and foreign money supply are: $M = M^* = \chi(1-\beta)^{-1}$.

3.2 The short-run equilibrium

In the next subsection, we will examine the effects of three types of shocks on the macroeconomic variables. In particular, we will examine the effects of these shocks by focusing on the degree of LCP.

Before turning to the analyses mentioned above, in this subsection, we first take a first-order approximation for each of Eqs.(78), (79) and (81) in the neighborhood of the initial steady state and consider the relationships between various variables. Now, from Eq.(78), we obtain the following equation:

$$\frac{2(\lambda-1)-(\psi-1)}{2(\lambda-1)}\frac{dn_t}{n}=\psi d\mu_t+\frac{\psi-1}{2}d\theta_t-\frac{(\psi-1)(2+s-s^*)}{4}d\varepsilon_t-\frac{dq_t}{\pi_F}+\frac{\psi-1}{2(\lambda-1)}\frac{dn_t^*}{n^*}. \tag{89}$$

Eq.(89) has the following characteristics under the assumption of $\lambda>\psi>1$. To begin with, a home monetary shock ($d\mu_t>0$) increases the sales revenues of home final goods firms through an increase in demand for final goods produced in the home country, which causes an increase in profits for these firms. Consequently, it encourages new entry into the home market. Next, a productivity shock in the home final goods sector ($d\theta_t>0$), since it increases the sales revenues of home final goods firms, increases profits for these firms. Consequently, it leads to the entry of new home final goods firms. Further, a depreciation ($d\varepsilon_t>0$), since it decreases overall home consumption through an increase in home CPI, decreases the sales revenues of home final goods firms, which causes a decrease in profits for these firms, and hence, the number of these firms decreases. Here, with regard to the relationship between the depreciation and the number of home final goods firms, there are two important points to note. First, when the degree of home LCP, i.e., s, rises, the decrease in the number of home final goods firms gets steeper. This is because a rise in s intensifies the increase in home CPI, which intensifies the decrease in overall home consumption, which intensifies the decrease in the sales revenues of home final goods firms and thereby intensifies the decrease in profits for these firms. Second, when the degree of foreign LCP, i.e., s^*, rises, it weakens the decrease in the number of home final goods firms. This is because a rise in s^* weakens the increase in home CPI, which weakens the decrease in overall home consumption, which weakens the decrease in the sales revenues of home final goods firms and thereby weakens the decrease in profits for these firms. Moreover, a productivity shock in the sector at the origin of the creation of the new home final goods ($d\nu_t>0$), which leads to a decrease in q_t, decreases the cost of entry and leads to the entry of new final goods firms in the home market. Finally, when the number of foreign final goods firms increases $\left(\frac{dn_t^*}{n^*} > 0\right)$, the foreign household's consumption of final goods produced in the home country increases, which causes an increase in the sales revenues of home final goods firms and thereby increases profits for these firms. Consequently, it encourages new entry into the home market.

From a first-order approximation of Eq.(79), we obtain the following equation:

$$\frac{2(\lambda-1)-(\psi-1)}{2(\lambda-1)}\frac{dn_t^*}{n^*} = \frac{\psi-1}{2}d\theta_t + \frac{(\psi-1)(2-s+s^*)}{4}d\varepsilon_t - \frac{dq_t^*}{\pi_F^*} + \frac{\psi-1}{2(\lambda-1)}\frac{dn_t}{n}. \tag{90}$$

Eq.(90) has the following characteristics under the assumption of $\lambda > \psi > 1$. To begin with, a productivity shock in the home final goods sector ($d\theta_t > 0$) encourages new entry into the foreign market, since it increases the sales revenues of foreign final goods firms, which causes the increase in profits for these firms. Next, the depreciation ($d\varepsilon_t > 0$), since it increases overall foreign consumption through the decrease in foreign CPI, increases the sales revenues of foreign final goods firms, which causes an increase in profits for these firms, and hence, the number of these firms increases. Here, with regard to the relationship between the depreciation and the number of foreign final goods firms, there are also two important points to note. First, when the value of s rises, the increase in the number of foreign final goods firms gets milder. This is because a rise in s weakens the decrease in foreign CPI, which weakens the increase in overall foreign consumption, which weakens the increase in the sales revenues of foreign final goods firms and thereby weakens the increase in profits for these firms. Second, when the value of s^* rises, the increase in the number of foreign final goods firms gets steeper. This is because a rise in s^* intensifies the decrease in foreign CPI, which intensifies the increase in overall foreign consumption, which intensifies the increase in the sales revenues of foreign final goods firms and thereby intensifies the increase in profits for these firms. Finally, when the number of home final goods firms increases $\left(\frac{dn_t}{n} > 0\right)$, the home household's consumption of final goods produced in the foreign country increases, which causes an increase in the sales revenues of foreign final goods firms and thereby increases profits for these firms. Consequently, it encourages new entry into the foreign market.

Combining Eqs.(89) and (90) and taking the first-order approximations of q_t in Eq.(89) and q_t^* in Eq.(90) in the neighborhood of the initial steady state, we obtain the following equation:

$$\left(\frac{\lambda-\psi}{\lambda-1}+\gamma\right)\frac{dn_t+dn_t^*}{n}=\psi d\mu_t+(\psi-1)d\theta_t+\psi d\nu_t-\psi\frac{s-s^*}{2}d\varepsilon_t. \quad (91)$$

Eq.(91) shows that a home monetary shock and the two types of home productivity shocks have a positive effect on the global number of final goods firms under the assumption of $\lambda>\psi>1$. At the same time, under this assumption, Eq.(91) also shows that the relationship between s and s^* determines the effect of a depreciation on the global number of final goods firms. This can be explained as follows. To begin with, a rise in s intensifies the decrease in the number of home final goods firms through the effect on profits, but it weakens the increase in the number of foreign final goods firms through the effects on both profits and entry costs. On the other hand, a rise in s^* weakens the decrease in the number of home final goods firms through the effects on both profits and entry costs, but it intensifies the increase in the number of foreign final goods firms through the effect on profits. If s is above s^*, a depreciation causes the above effect based on a rise in s to dominate that based on a rise in s^*. This decreases the global number of final goods firms. Conversely, if s is below s^*, a depreciation causes the above effect based on a rise in s^* to dominate that based on a rise in s. This increases the global number of final goods firms.

From the first-order approximation of Eq.(81), we obtain the following equation:

$$\left(\psi+\frac{(\lambda-1)(s+s^*)}{2}\right)d\varepsilon_t=\psi d\mu_t-(\lambda-1)d\theta_t-\left(\frac{dn_t}{n}-\frac{dn_t^*}{n^*}\right). \quad (92)$$

Eq.(92) has the following characteristics under the assumption of $\lambda>\psi>1$. To begin with, a home monetary shock ($d\mu_t>0$) leads to a depreciation of the nominal exchange rate. The balance of payments equilibrium is restored via the depreciation, since such a shock leads only to the increase in imports of foreign final goods. Next, a productivity shock in the home final goods sector ($d\theta_t>0$) leads to an appreciation of the nominal exchange rate. The balance of payments equilibrium is restored via the appreciation, since such a shock lowers the home-currency prices of home final goods, which causes an increase in the net export of final goods. Finally, an increase in the relative number of final goods firms located in the home country $\left(\frac{dn_t}{n}-\frac{dn_t^*}{n^*}>0\right)$ leads to an appreciation of the nominal exchange rate.

The balance of payments equilibrium is restored via the appreciation, since such an increase also leads to an increase in the net export of final goods. Here, from Eq.(92), we get $\frac{d(\partial d\varepsilon_t/\partial d\mu_t)}{ds} < 0$, $\frac{d(\partial d\varepsilon_t/\partial d\mu_t)}{ds^*} < 0$, $\frac{d(\partial d\varepsilon_t/\partial d\theta_t)}{ds} > 0$, $\frac{d(\partial d\varepsilon_t/\partial d\theta_t)}{ds^*} > 0$, $\frac{d\left(\partial d\varepsilon_t/\partial\left(\frac{dn_t}{n}-\frac{dn_t^*}{n^*}\right)\right)}{ds} > 0$ and $\frac{d\left(\partial d\varepsilon_t/\partial\left(\frac{dn_t}{n}-\frac{dn_t^*}{n^*}\right)\right)}{ds^*} > 0$. This shows that the degrees of depreciation and appreciation, which are based on these shocks, gets milder.

3.3 The effects of the three types of shocks on macroeconomic variables

3.3.1 Monetary shock

Using Eqs.(89), (90), (91) and (92), we now turn to the analyses of the effects of the three types of shocks. We first focus on the home monetary shock ($d\mu_t > 0$). To simplify the analysis, we present the results of the two scenarios of (i) $\gamma > 0$, $0 < \delta < 1$ and $\psi = 1$, and (ii) $\gamma = 0$ and $\lambda > \psi > 1$.

Our first result is that, in scenario (i), a home monetary shock unambiguously leads to a depreciation of the nominal exchange rate:

$$\frac{d\varepsilon_t}{d\mu_t} = \frac{2\gamma(1-\delta)}{\Delta} > 0, \tag{93}$$

where $\Delta \equiv [1+\delta+\gamma(1-\delta)][2+(\lambda-1)(s+s^*)]-(1+\delta)(2-s-s^*) > 0$. Note that the degree of depreciation decreases in response to the rise in s and/or s^*.[18] This can be explained as follows. From Eq.(89), the larger the value of s^*, the lower the entry costs for home final goods firms. On the other hand, from Eq.(90), the larger the value of s, the higher the entry costs for foreign final goods firms. These lead to the entry of home final goods firms and the exit of foreign final goods firms, which causes the increase in the relative number of home final goods firms, and hence, the degree of trade deficit decreases. In addition, when the value of s and/or s^*, which is the component of coefficient of $d\varepsilon_t$ in Eq.(92), rises, the degree of trade deficit also decreases. Consequently, from these two perspectives, the degree of depreciation, which is required to correct the resulting trade deficit, decreases.

Next, the effect of a home monetary shock on the number of home final goods firms is unambiguously positive, while that on the number of foreign

[18] When $s = s^* = 0$, the value of Eq.(93) is unity. That is, under such a circumstance, the nominal exchange rate depreciates in proportion to the size of home monetary shock.

final goods firms is ambiguous:

$$\frac{dn_t}{d\mu_t}\frac{1}{n} = \frac{1}{(1+\gamma)[1+\delta+\gamma(1-\delta)]}\left((1+\delta+\gamma) - \frac{\gamma(1-\delta)[\gamma\delta(1-s)+(1+\delta+\gamma)(1-s^*)]}{\Delta}\right) > 0, \tag{94}$$

$$\frac{dn_t^*}{d\mu_t}\frac{1}{n^*} = -\frac{\gamma}{(1+\gamma)[1+\delta+\gamma(1-\delta)]}\left(\gamma\delta - \frac{\gamma(1-\delta)[(1+\delta+\gamma)(1-s)+\gamma\delta(1-s^*)]}{\Delta}\right). \tag{95}$$

The reason why these results are obtained is that while this shock brings more profits for home final goods firms than entry costs for home final goods firms, in the foreign country it only has the effect of an increase (or decrease) in the entry costs for foreign final goods firms (see Eqs.(89), (90) and (93)). If both s and s^* take relatively small values, the effect of this shock on the number of foreign final goods firms has the potential to become positive, since this shock has the potential to decrease the entry costs for foreign final goods firms. Here, differentiating both Eqs.(94) and (95) with respect to s and s^*, we can show that the rise in s and/or s^* intensifies the increase in the number of home final goods firms, while it weakens the increase in (or intensifies the decrease in) the number of foreign final goods firms. This can be explained as follows. The larger the value of s and/or s^*, the lower the degree of the increase in the entry costs for home final goods firms. On the other hand, the larger the value of s and/or s^*, the lower the degree of the decrease in (or the higher the degree of the increase in) the entry costs for foreign final goods firms. These intensify the entry of home final goods firms and weaken the entry (or intensify the exit) of foreign final goods firms, and hence, the degree of the increase in the number of home final goods firms strengthens, and that of foreign final goods firms weakens (or the degree of the decrease in the number of foreign final goods firms strengthens).

In scenario (ii), the effect of a home monetary shock on the nominal exchange rate is as follows:

$$\frac{d\varepsilon_t}{d\mu_t} = 0. \tag{96}$$

Eq.(96) shows that a home monetary shock has no effect on the nominal exchange rate. That is, this equation shows an entirely-different result from the conventional wisdom that a home monetary shock has a positive effect on the nominal exchange rate. The reason why this result is obtained is that the assumption of $\gamma = 0$ plays a crucial role in our model. This assumption usually produces an absence of trade account imbalances. Therefore, a home monetary shock leaves the nominal exchange rate unchanged.

In scenario (ii), the effects of a home monetary shock on the number of home and foreign final goods firms are as follows:

$$\frac{dn_t}{d\mu_t}\frac{1}{n} = \psi\left(\frac{2\lambda - \psi - 1}{2(\lambda - \psi)}\right) > 0, \tag{97}$$

$$\frac{dn_t^*}{d\mu_t}\frac{1}{n^*} = \frac{\psi(\psi - 1)}{2(\lambda - \psi)} > 0. \tag{98}$$

Eqs.(97) and (98) show that the effects of this shock on the number of home and foreign final goods firms are positive. In addition, these equations also show that the effect of this shock on the number of home final goods firms exceeds that on the number of foreign final goods firms. Further, these equations show that the effects of this shock on the number of home and foreign final goods firms are independent of the degrees of home and foreign LCPs. The last point depends crucially on the result shown in Eq.(96). The reason why this point is shown is that the disappearance of the exchange rate channel removes LCP parameters completely from Eqs.(89) and (90), which are the home and foreign free entry conditions, and Eq.(92), which is the balance of payments of the home country. Therefore, the effects of this shock on the number of home and foreign final goods firms are shown excluding LCP parameters.

In the rest of the analysis, we only present the result of the scenario (i), since the remaining macroeconomic variables in scenario (ii) cannot be analyzed from the perspective of the degrees of home and foreign LCPs either. To begin with, we consider the effects of a home monetary shock on home and foreign CPIs. Here, the effect of this shock on home CPI is as follows:

$$\frac{dP_t}{d\mu_t}\frac{1}{P} = -\frac{1}{2(\lambda - 1)}\left(\frac{dn_t}{d\mu_t}\frac{1}{n} + \frac{dn_t^*}{d\mu_t}\frac{1}{n^*} - \frac{(\lambda - 1)(2 + s - s^*)}{2}\frac{d\varepsilon_t}{d\mu_t}\right). \tag{99}$$

As shown in Eq.(99), the effect of this shock on home CPI can be separated into two channels: the global number of final goods firms, and the nominal exchange rate. The former channel is negative, but the latter channel is positive. Therefore, the overall effect of this shock is ambiguous.[19] However, if $s > s^*$ ($s < s^*$), the overall effect of this shock has the potential to become

[19]More properly, the effect of a home monetary shock on home CPI is shown by the following three channels $\left(\frac{dP_t}{d\mu_t}\frac{1}{P} = -\frac{1}{2(\lambda-1)}\left(\frac{dn_t}{d\mu_t}\frac{1}{n} + \frac{dn_t^*}{d\mu_t}\frac{1}{n^*}\right) + \frac{1-s^*}{2}\frac{d\varepsilon_t}{d\mu_t} + \frac{s+s^*}{4}\frac{d\varepsilon_t}{d\mu_t}\right)$. To

positive (negative), since the effect of the latter (former) channel has the potential to exceed that of the former (latter) channel.[20] Here, when $s = s^*$, the rise in s weakens the increase in (or intensifies the decrease in) home CPI. This can be explained by the decline in the degree of the increase in the latter channel due to the rise in this value.

The effect of a home monetary shock on foreign CPI is as follows:

$$\frac{dP_t^*}{d\mu_t}\frac{1}{P^*} = -\frac{1}{2(\lambda-1)}\left(\frac{dn_t}{d\mu_t}\frac{1}{n} + \frac{dn_t^*}{d\mu_t}\frac{1}{n^*} + \frac{(\lambda-1)(2-s+s^*)}{2}\frac{d\varepsilon_t}{d\mu_t}\right) < 0. \tag{100}$$

Again, there are two channels: the global number of final goods firms, and the nominal exchange rate. Unlike in the case of the home country, both of these channels are negative. Therefore, the overall effect of this shock is negative. This is determined independently of home and foreign LCP parameters. In addition, when $s = s^*$, the rise in s weakens the decrease in foreign CPI. This can be explained by the decline in the degree of the decrease in the latter channel due to the rise in this value.

Next, we consider the effects of a home monetary shock on overall home consumption $C_t(\equiv \mu_t/P_t)$ and overall foreign consumption $C_t^*(\equiv \mu_t^*/P_t^*)$. Although the effect of this shock on home CPI is ambiguous, the effect of this shock on C_t is positive. Here, from the definition of C_t and the condition of $s = s^*$, when the increase (or decrease) in home CPI weakens (or intensifies), the increase in C_t intensifies. By the same token, the effect of this shock on C_t^* is also positive, since the effect of this shock on foreign CPI is always negative. Here, from the definition of C_t^* and the condition of $s = s^*$, when the decrease in foreign CPI weakens, the increase in C_t^* weakens.

Finally, we consider the effects of a home monetary shock on the em-

begin with, when a home monetary shock occurs, the global number of final goods firms increases, which causes a decline in the home-currency prices of final goods through an increase in the supply of final goods in terms of the world as a whole. Consequently, the effect of this channel on home CPI is negative. Next, when this shock occurs, the nominal exchange rate depreciates, which causes a rise in the home-currency prices of home final goods under circumstances other than $s^* = 1$. Consequently, the effect of this channel on home CPI is positive under such circumstances. Finally, when this shock occurs, the nominal exchange rate depreciates, which causes a deterioration in the terms of trade under circumstances other than $s = s^* = 0$. Consequently, the effect of this channel on home CPI is positive under such circumstances.

[20]For example, when $s > s^*$ ($s < s^*$) and γ takes a relatively large (small) value, the effect of a home monetary shock on home CPI has the potential to become positive (negative).

ployment levels of both countries. Here, the effect of this shock on home employment is as follows:

$$\frac{d\ell_t}{d\mu_t}\frac{1}{\ell} = \frac{1}{2}\left((1+\gamma)\left(\frac{dn_t}{d\mu_t}\frac{1}{n} + \frac{dn_t^*}{d\mu_t}\frac{1}{n^*}\right) + \frac{(\lambda-1)(2-s-s^*)}{2\lambda}\frac{d\varepsilon_t}{d\mu_t}\right) > 0. \quad (101)$$

As with the case of the effects of this shock on both countries' CPIs, there are two channels: the global number of final goods firms, and the nominal exchange rate. Both of these channels are positive. Therefore, the overall effect of this shock is positive.[21] This is determined independently of home and foreign LCP parameters. In addition, when $s = s^*$, the rise in s weakens the increase in home employment. This can be explained by the decline in the degree of the increase in the latter channel due to the rise in this value.

[21] More precisely, the effect of a home monetary shock on home employment is shown by the effects through two macroeconomic variables of $Y_{h,t}$, which is a composite of home intermediate inputs used by home final goods firms, and $Y_{h,t}^*$, which is a composite of home intermediate inputs used by foreign final goods firms. The effect of this shock on $Y_{h,t}$ is shown by the following three channels $\left(\frac{dY_{h,t}}{d\mu_t}\frac{1}{Y_h} = \frac{dn_t}{d\mu_t}\frac{1}{n} + \frac{d\pi_{F,t}}{d\mu_t}\frac{1}{\pi_F} - \frac{1-s^*}{2\lambda}\frac{d\varepsilon_t}{d\mu_t}\right)$. To begin with, when this shock occurs, the number of home final goods firms increases, which causes the increase in the supply of home final goods. This intensifies the home final goods firms' demands for a composite of the inputs produced by home intermediate goods firms. Consequently, the effect of this channel on $Y_{h,t}$ is positive. Next, when this shock occurs, the profits earned by home final goods firms increase, which causes an increase in the supply of home final goods. This intensifies the home final goods firms' demands for a composite of the inputs produced by home intermediate goods firms. Consequently, the effect of this channel on $Y_{h,t}$ is positive. Finally, when this shock occurs, the nominal exchange rate depreciates. Under circumstances other than $s^* = 1$, this raises the home-currency price that corresponds to a composite of the inputs produced by foreign intermediate goods firms, which causes a decrease in the home final goods firms' demands for a composite of the inputs produced by foreign intermediate goods firms. The decrease in this demand leads to the decrease in the home final goods firms' outputs, and hence, the home final goods firms' demand for a composite of the inputs produced by home intermediate goods firms declines. Consequently, the effect of this channel on $Y_{h,t}$ is negative under such circumstances. The effect of this shock on $Y_{h,t}^*$ can be also shown by the three channels $\left(\frac{dY_{h,t}^*}{d\mu_t}\frac{1}{Y_h^*} = \frac{dn_t^*}{d\mu_t}\frac{1}{n^*} + \frac{d\pi_{F,t}^*}{d\mu_t}\frac{1}{\pi_F^*} + \frac{(2\lambda-1)(1-s)}{2\lambda}\frac{d\varepsilon_t}{d\mu_t}\right)$. Unlike in the case of $Y_{h,t}$, the effect of a depreciation on $Y_{h,t}^*$ is positive under circumstances other than $s = 1$. This can be explained as follows. When the nominal exchange rate depreciates, the foreign-currency price that corresponds to a composite of the inputs produced by home intermediate goods firms declines. This causes the increase in the foreign final goods firms' demand for a composite of the inputs produced by home intermediate goods firms. Consequently, the effect of this channel on $Y_{h,t}^*$ is positive under such circumstances.

The effect of a home monetary shock on foreign employment is as follows:

$$\frac{d\ell_t^*}{d\mu_t}\frac{1}{\ell^*} = \frac{1}{2}\left((1+\gamma)\left(\frac{dn_t}{d\mu_t}\frac{1}{n} + \frac{dn_t^*}{d\mu_t}\frac{1}{n^*}\right) - \frac{(\lambda-1)(2-s-s^*)}{2\lambda}\frac{d\varepsilon_t}{d\mu_t}\right) > 0. \tag{102}$$

Again, there are two channels: the global number of final goods firms, and the nominal exchange rate. Although the former channel is positive and the latter channel is negative, the effect of the former channel exceeds that of the latter channel. Therefore, the overall effect of this shock is also positive. In addition, when $s = s^*$, the rise in s intensifies the increase in foreign employment. This can be explained by the decline in the degree of the decrease in the latter channel due to the rise in this value.

3.3.2 Productivity shocks

In this subsubsection, we examine the effects of the two types of home productivity shocks. To begin with, in scenario (i), a productivity shock in the home final goods sector ($d\theta_t > 0$) leads to an appreciation of the nominal exchange rate:

$$\frac{d\varepsilon_t}{d\theta_t} = -\frac{2(\lambda-1)[1+\delta+\gamma(1-\delta)]}{\Delta} < 0. \tag{103}$$

Note that the degree of appreciation decreases in response to the rise in s and/or s^*. This can be explained as follows. From Eq.(89), the larger the value of s^*, the higher the entry costs for home final goods firms. On the other hand, from Eq.(90), the larger the value of s, the lower the entry costs for foreign final goods firms. These lead to an exit of home final goods firms and an entry of foreign final goods firms, which causes a decrease in the relative number of home final goods firms, and hence, a decrease in the trade surplus. In addition, when the value of s and/or s^*, which is the component of coefficient of $d\varepsilon_t$ in Eq.(92), rises, the trade surplus also decreases. Consequently, from these two perspectives, the degree of appreciation, which is required to correct the resulting trade surplus, decreases.

Next, the effect of a productivity shock in the home final goods sector on the number of home final goods firms is non-negative, while that on the number of foreign final goods firms is non-positive:

$$\frac{dn_t}{d\theta_t}\frac{1}{n} = \frac{(\lambda-1)[\gamma\delta(1-s)+(1+\delta+\gamma)(1-s^*)]}{(1+\gamma)\Delta} \geq 0, \tag{104}$$

$$\frac{dn_t^*}{d\theta_t}\frac{1}{n^*} = -\frac{(\lambda-1)[(1+\delta+\gamma)(1-s)+\gamma\delta(1-s^*)]}{(1+\gamma)\Delta} \leq 0. \tag{105}$$

The reason why these results are obtained is that while this shock prevents the entry costs for home final goods firms from increasing, in the foreign country it prevents the entry costs for foreign final goods firms from decreasing (see Eqs.(89), (90) and (103)). Here, differentiating both Eqs.(104) and (105) with respect to s and s^*, we can show that the rise in s and/or s^* weakens both the increase in the number of home final goods firms and the decrease in the number of foreign final goods firms. This can be explained as follows. The larger the value of s and/or s^*, the lower the degree of the decrease in the entry costs for home final goods firms. By the same token, the larger the value of s and/or s^*, the lower the degree of the increase in the entry costs for foreign final goods firms. These weaken both the degree of entry of home final goods firms and the degree of exit of foreign final goods firms. Consequently, both the degree of the increase in the number of home final goods firms and the degree of the decrease in the number of foreign final goods firms weaken.

In scenario (ii), the effect of a productivity shock in the home final goods sector on the nominal exchange rate is as follows:[22]

$$\frac{d\varepsilon_t}{d\theta_t} = -\frac{2(\lambda-1)}{\lambda(s+s^*)} < 0. \tag{106}$$

Eq.(106) shows that this productivity shock leads to an appreciation of the nominal exchange rate. In addition, as shown in Eq.(103), Eq.(106) also shows that the degree of appreciation decreases in response to the rise in s and/or s^*.

In scenario (ii), the effects of a productivity shock in the home final goods sector on the number of home and foreign final goods firms are as follows:

$$\frac{dn_t}{d\theta_t}\frac{1}{n} = \frac{(\lambda-1)[(\lambda-\psi)(\psi-s^*)+(\psi-1)\lambda s]}{\lambda(\lambda-\psi)(s+s^*)} > 0, \tag{107}$$

$$\frac{dn_t^*}{d\theta_t}\frac{1}{n^*} = \frac{\psi(\lambda-1)[(\lambda-1)s-(\lambda-\psi)]}{\lambda(\lambda-\psi)(s+s^*)}. \tag{108}$$

Eq.(107) shows that the effect of this shock on the number of home final goods firms is positive, while Eq.(108) shows that the effect of this shock

[22] In scenario (ii), we assume the circumstances other than $s = s^* = 0$.

on the number of foreign final goods firms is ambiguous. The result shown in Eq.(108) is different from that shown in Eq.(105). The reason why this difference is produced is that the right hand side of Eq.(90), which is required to derive Eqs.(105) and (108), takes both positive and negative values under different values of s only in the case of the derivation in Eq.(108).

In the rest of the analysis of a productivity shock in the home final goods sector, we only present the result of the scenario (i). To begin with, we consider the effects of this shock on home and foreign CPIs. Here, the effect of this shock on home CPI is as follows:

$$\frac{dP_t}{d\theta_t}\frac{1}{P} = -\frac{1}{2(\lambda-1)}\left(\frac{dn_t}{d\theta_t}\frac{1}{n} + \frac{dn_t^*}{d\theta_t}\frac{1}{n^*} - \frac{(\lambda-1)(2+s-s^*)}{2}\frac{d\varepsilon_t}{d\theta_t} + (\lambda-1)\right) < 0. \tag{109}$$

As shown in Eq.(109), the effect of this shock on home CPI can be separated into three channels: the global number of final goods firms, the nominal exchange rate, and the constant term. Although both the second and the third channels are negative, the first channel is ambiguous. However, the sum of the second and the third channels plays a critical role in the effect of this shock on home CPI. Therefore, the overall effect of this shock is negative.[23] This is determined independently of home and foreign LCP parameters. In addition, when $s = s^*$, the rise in s weakens the decrease in home CPI. This can be explained by the weakening of the decrease in the second channel due to the rise in this value.

The effect of a productivity shock in the home final goods sector on foreign

[23]More precisely, the effect of a productivity shock in the home final goods sector on home CPI is shown by the following four channels $\left(\frac{dP_t}{d\theta_t}\frac{1}{P} = -\frac{1}{2(\lambda-1)}\left(\frac{dn_t}{d\theta_t}\frac{1}{n} + \frac{dn_t^*}{d\theta_t}\frac{1}{n^*}\right) + \frac{1-s^*}{2}\frac{d\varepsilon_t}{d\theta_t} + \frac{1}{2}\left(1 + \frac{s+s^*}{2}\frac{d\varepsilon_t}{d\theta_t}\right) - 1\right)$. To begin with, when a productivity shock in the home final goods sector occurs under a circumstance of $s < s^*$ ($s > s^*$), the global number of final goods firms increases (or decreases), which causes a decline (or rise) in the home-currency prices of final goods through the increase (or decrease) in the supply of final goods in terms of the world as a whole. Consequently, the effect of this channel on home CPI is negative (or positive). Next, when this productivity shock occurs, the nominal exchange rate appreciates, which causes a decline in the home-currency prices of home final goods under circumstances other than $s^* = 1$. Consequently, the effect of this channel on home CPI is negative under such circumstances. Further, when this productivity shock occurs, the nominal exchange rate appreciates, which basically causes a deterioration in the terms of trade. Consequently, the effect of this channel on home CPI is positive. Finally, when this productivity shock occurs, the unit cost of production for home final goods decreases, which causes a decline in the home-currency prices of home final goods. Consequently, the effect of this channel on home CPI is negative.

CPI is as follows:

$$\frac{dP_t^*}{d\theta_t}\frac{1}{P^*} = -\frac{1}{2(\lambda-1)}\left(\frac{dn_t}{d\theta_t}\frac{1}{n} + \frac{dn_t^*}{d\theta_t}\frac{1}{n^*} + \frac{(\lambda-1)(2-s+s^*)}{2}\frac{d\varepsilon_t}{d\theta_t} + (\lambda-1)\right). \tag{110}$$

Again, there are three channels: the global number of final goods firms, the nominal exchange rate, and the constant term. Although the second channel is positive and the third channel is negative, the first channel is ambiguous. Therefore, the overall effect of this shock is ambiguous. However, if $s > s^*$ ($s < s^*$), the overall effect of this shock has the potential to become negative (positive), since the effects of the first and the third (second) channels have the potential to exceed that of the second (third) channel.[24] Here, when $s = s^*$, the rise in s weakens the increase in (or intensifies the decrease in) foreign CPI. This can be explained by the decline in the degree of the increase in the second channel due to the rise in this value.

Next, we consider the effects of a productivity shock in the home final goods sector on overall home consumption C_t and overall foreign consumption C_t^*. The effect of this shock on C_t is positive, since the effect of this shock on home CPI is negative. On the other hand, the effect of this shock on C_t^* is ambiguous, since the effect of this shock on foreign CPI is ambiguous. Here, from the definition of C_t and the condition of $s = s^*$, when the decrease in home CPI weakens, the increase in C_t weakens. By the same token, from the definition of C_t^* and the condition of $s = s^*$, when the increase (or decrease) in foreign CPI weakens (or intensifies), the decrease (or increase) in C_t^* weakens (or intensifies).

Finally, we consider the effects of a productivity shock in the home final goods sector on the employment levels of both countries. Here, the effect of this shock on home employment is as follows:

$$\frac{d\ell_t}{d\theta_t}\frac{1}{\ell} = \frac{1}{2}\left((1+\gamma)\left(\frac{dn_t}{d\theta_t}\frac{1}{n} + \frac{dn_t^*}{d\theta_t}\frac{1}{n^*}\right) + \frac{(\lambda-1)(2-s-s^*)}{2\lambda}\frac{d\varepsilon_t}{d\theta_t}\right). \tag{111}$$

As shown in Eq.(111), the effect of this shock on home employment can be separated into two channels: the global number of final goods firms, and the nominal exchange rate. Although the latter channel is negative, the

[24]For example, under the values of five parameters used in Section 4, if $s > s^*$ ($s < s^*$), the effect of a productivity shock in the home final goods sector on foreign CPI has the potential to become negative (positive).

former channel is ambiguous. Therefore, the overall effect of this shock is ambiguous.[25] Here, when $s = s^*$, the overall effect of this shock is negative. In addition, under such a circumstance, the rise in s weakens the decrease in home employment. This can be explained by the decline in the degree of the decrease in the latter channel due to the rise in this value.

The effect of a productivity shock in the home final goods sector on foreign employment is as follows:

$$\frac{d\ell_t^*}{d\theta_t}\frac{1}{\ell^*} = \frac{1}{2}\left((1+\gamma)\left(\frac{dn_t}{d\theta_t}\frac{1}{n} + \frac{dn_t^*}{d\theta_t}\frac{1}{n^*}\right) - \frac{(\lambda-1)(2-s-s^*)}{2\lambda}\frac{d\varepsilon_t}{d\theta_t}\right). \quad (112)$$

[25]More precisely, the effect of a productivity shock in the home final goods sector on home employment is shown through the effects on two macroeconomic variables: $Y_{h,t}$, which is a composite of home intermediate inputs used by home final goods firms, and $Y_{h,t}^*$, which is a composite of home intermediate inputs used by foreign final goods firms. The effect of this productivity shock on $Y_{h,t}$ is shown by the following three channels $\left(\frac{dY_{h,t}}{d\theta_t}\frac{1}{Y_h} = \frac{dn_t}{d\theta_t}\frac{1}{n} + \frac{d\pi_{F,t}}{d\theta_t}\frac{1}{\pi_F} - \frac{1-s^*}{2\lambda}\frac{d\varepsilon_t}{d\theta_t}\right)$. To begin with, when this productivity shock occurs under circumstances other than $s = s^* = 1$, the number of home final goods firms increases, which causes an increase in the supply of home final goods. This intensifies the home final goods firms' demand for a composite of the inputs produced by home intermediate goods firms. Consequently, the effect of this channel on $Y_{h,t}$ is positive under such circumstances. Next, under circumstances other than $s = s^* = 1$, when this productivity shock occurs, the profits earned by home final goods firms decrease, which causes a decrease in the supply of home final goods. This weakens the home final goods firms' demand for a composite of the inputs produced by home intermediate goods firms. Consequently, the effect of this channel on $Y_{h,t}$ is negative under such circumstances. Finally, when this productivity shock occurs, the nominal exchange rate appreciates. Under circumstances other than $s^* = 1$, this brings down the home-currency price that corresponds to a composite of the inputs produced by foreign intermediate goods firms, which causes an increase in the home final goods firms' demand for a composite of the inputs produced by foreign intermediate goods firms. The increase in this demand leads to the increase in the home final goods firms' output, and hence, the home final goods firms' demand for a composite of the inputs produced by home intermediate goods firms rises. Consequently, the effect of this channel on $Y_{h,t}$ is positive under such circumstances. The effect of this productivity shock on $Y_{h,t}^*$ can be also shown by the three channels $\left(\frac{dY_{h,t}^*}{d\theta_t}\frac{1}{Y_h^*} = \frac{dn_t^*}{d\theta_t}\frac{1}{n^*} + \frac{d\pi_{F,t}^*}{d\theta_t}\frac{1}{\pi_F^*} + \frac{(2\lambda-1)(1-s)}{2\lambda}\frac{d\varepsilon_t}{d\theta_t}\right)$. Unlike in the case of $Y_{h,t}$, the effect of an appreciation on $Y_{h,t}^*$ is negative under circumstances other than $s = 1$. This can be explained as follows. When the nominal exchange rate appreciates, the foreign-currency price that corresponds to a composite of the inputs produced by home intermediate goods firms rises. This causes a decrease in the foreign final goods firms' demand for a composite of the inputs produced by home intermediate goods firms. Consequently, the effect of this channel on $Y_{h,t}^*$ is negative under such circumstances.

Again, there are two channels: the global number of final goods firms, and the nominal exchange rate. Although the latter channel is positive, the former channel is ambiguous. Therefore, the overall effect of this shock is also ambiguous. Here, when $s = s^*$, the overall effect of this shock is positive. In addition, under such a circumstance, the rise in s weakens the increase in foreign employment. This can be explained by the decline in the degree of the increase in the latter channel due to the rise in this value.

We now examine the effects of a productivity shock in the sector at the origin of the creation of the new final goods in the home country ($d\nu_t > 0$). To begin with, in scenario (i), this shock leads to an appreciation of the nominal exchange rate:

$$\frac{d\varepsilon_t}{d\nu_t} = -\frac{2(1+\delta)}{\Delta} < 0. \tag{113}$$

As with the result obtained from Eq.(103), the result obtained from Eq.(113) also shows that the degree of appreciation decreases in response to the rise in s and/or s^*. The logic of this mechanism is the same as that for the result obtained from Eq.(103).

Next, the effect of a productivity shock in the sector at the origin of the creation of the new final goods in the home country on the number of home final goods firms is positive, while that on the number of foreign final goods firms is negative:

$$\frac{dn_t}{d\nu_t}\frac{1}{n} = \frac{1}{2}\left(\frac{1}{1+\gamma} + \frac{1+\delta}{1+\delta+\gamma(1-\delta)}\right) + \frac{(1+\delta)[\gamma\delta(1-s)+(1+\delta+\gamma)(1-s^*)]}{(1+\gamma)[1+\delta+\gamma(1-\delta)]\Delta} > 0, \tag{114}$$

$$\frac{dn_t^*}{d\nu_t}\frac{1}{n^*} = \frac{1}{2}\left(\frac{1}{1+\gamma} - \frac{1+\delta}{1+\delta+\gamma(1-\delta)}\right) - \frac{(1+\delta)[(1+\delta+\gamma)(1-s)+\gamma\delta(1-s^*)]}{(1+\gamma)[1+\delta+\gamma(1-\delta)]\Delta} < 0. \tag{115}$$

The reason why these results are obtained is that while this shock lowers the entry costs for home final goods firms, in the foreign country it raises the entry costs for foreign final goods firms (see Eqs.(89), (90) and (113)). Here, differentiating both Eqs.(114) and (115) with respect to s and s^*, we can show that the rise in s and/or s^* weakens both the increase in the number of home final goods firms and the decrease in the number of foreign final goods firms. The logic of this mechanism is also the same as that for the results obtained from Eqs.(104) and (105).

In scenario (ii), the effect of a productivity shock in the sector at the origin of the creation of the new final goods in the home country on the nominal exchange rate is as follows:[26]

$$\frac{d\varepsilon_t}{d\nu_t} = -\frac{2}{\lambda(s+s^*)} < 0. \tag{116}$$

As with the result obtained from Eq.(106), Eq.(116) also shows that this productivity shock leads also to an appreciation of the nominal exchange rate. In addition, as shown in Eq.(113), Eq.(116) also shows that the degree of appreciation decreases in response to the rise in s and/or s^*.

In scenario (ii), the effects of a productivity shock in the sector at the origin of the creation of the new final goods in the home country on the number of home and foreign final goods firms are as follows:

$$\frac{dn_t}{d\nu_t}\frac{1}{n} = \frac{\lambda(\lambda-1)(s+s^*)+\psi(\lambda-\psi)}{\lambda(\lambda-\psi)(s+s^*)} > 0, \tag{117}$$

$$\frac{dn_t^*}{d\nu_t}\frac{1}{n^*} = \frac{\psi[(\lambda-1)(s+s^*)-(\lambda-\psi)]}{\lambda(\lambda-\psi)(s+s^*)}. \tag{118}$$

As with the results obtained from Eqs.(107) and (108), Eq.(117) shows that the effect of this shock on the number of home final goods firms is positive, while Eq.(118) shows that the effect of this shock on the number of foreign final goods firms is ambiguous. The result shown in Eq.(118) is also different from that shown in Eq.(115). The explanation for this difference is the same as that for the difference between Eqs.(105) and (108).

In the rest of the analysis of a productivity shock in the sector at the origin of the creation of the new final goods in the home country, we again present only the result of the scenario (i). To begin with, we consider the effects of this shock on home and foreign CPIs. Here, the effect of this shock on home CPI is as follows:

$$\frac{dP_t}{d\nu_t}\frac{1}{P} = -\frac{1}{2(\lambda-1)}\left(\frac{dn_t}{d\nu_t}\frac{1}{n} + \frac{dn_t^*}{d\nu_t}\frac{1}{n^*} - \frac{(\lambda-1)(2+s-s^*)}{2}\frac{d\varepsilon_t}{d\nu_t}\right) < 0. \tag{119}$$

As shown in Eq.(119), the effect of this shock on home CPI can be separated into two channels: the global number of final goods firms, and the

[26] As with the scenario (ii) of the analysis of a productivity shock in the home final goods sector, in this scenario of the analysis of this shock, we again assume circumstances other than $s = s^* = 0$.

nominal exchange rate. Both of these channels are negative. Therefore, the overall effect of this shock is negative.[27] This is determined independently of home and foreign LCP parameters. In addition, when $s = s^*$, the rise in s weakens the decrease in home CPI. This can be explained by the decline in the degree of the decrease in the latter channel due to the rise in this value.

The effect of a productivity shock in the sector at the origin of the creation of the new final goods in the home country on foreign CPI is as follows:

$$\frac{dP_t^*}{d\nu_t}\frac{1}{P^*} = -\frac{1}{2(\lambda-1)}\left(\frac{dn_t}{d\nu_t}\frac{1}{n} + \frac{dn_t^*}{d\nu_t}\frac{1}{n^*} + \frac{(\lambda-1)(2-s+s^*)}{2}\frac{d\varepsilon_t}{d\nu_t}\right). \quad (120)$$

Again, there are two channels: the global number of final goods firms, and the nominal exchange rate. Unlike in the case of the home country, the former channel is negative, but the latter channel is positive. Therefore, the overall effect of this shock is ambiguous. However, if $s > s^*$ ($s < s^*$), the overall effect of this shock has the potential to become negative (positive), since the former (latter) channel has the potential to exceed the latter (former) channel.[28] Here, when $s = s^*$, the rise in s weakens the increase in (or intensifies the decrease in) foreign CPI. This can be explained by the decline in the degree of the increase in the latter channel due to the rise in this value.

Next, we consider the effects of a productivity shock in the sector at the origin of the creation of the new final goods in the home country on overall home consumption C_t and overall foreign consumption C_t^*. The effect of this

[27] More precisely, the effect of a productivity shock in the sector at the origin of the creation of the new final goods in the home country on home CPI is shown by the following three channels $\left(\frac{dP_t}{d\nu_t}\frac{1}{P} = -\frac{1}{2(\lambda-1)}\left(\frac{dn_t}{d\nu_t}\frac{1}{n} + \frac{dn_t^*}{d\nu_t}\frac{1}{n^*}\right) + \frac{1-s^*}{2}\frac{d\varepsilon_t}{d\nu_t} + \frac{s+s^*}{4}\frac{d\varepsilon_t}{d\nu_t}\right)$. To begin with, when a productivity shock in the sector at the origin of the creation of the new final goods in the home country occurs, the global number of final goods firms increases, which causes a decline in the home-currency prices of final goods through the increase in the supply of final goods in terms of the world as a whole. Consequently, the effect of this channel on home CPI is negative. Next, when this productivity shock occurs, the nominal exchange rate appreciates, which causes a decline in the home-currency prices of home final goods under circumstances other than $s^* = 1$. Consequently, the effect of this channel on home CPI is negative under such circumstances. Finally, when this productivity shock occurs, the nominal exchange rate appreciates, which causes an improvement in the terms of trade under circumstances other than $s = s^* = 0$. Consequently, the effect of this channel on home CPI is negative under such circumstances.

[28] For example, when $s > s^*$ ($s < s^*$) and λ takes a relatively small (large) value, the effect of a productivity shock in the sector at the origin of the creation of the new final goods in the home country on foreign CPI has the potential to become negative (positive).

shock on C_t is positive, since the effect of this shock on home CPI is negative. On the other hand, the effect of this shock on C_t^* is ambiguous, since the effect of this shock on foreign CPI is ambiguous. Here, from the definition of C_t and the condition of $s = s^*$, when the decrease in home CPI weakens, the increase in C_t weakens. By the same taken, from the definition of C_t^* and the condition of $s = s^*$, when the increase (or decrease) in foreign CPI weakens (or intensifies), the decrease (or increase) in C_t^* weakens (or intensifies).

Finally, we consider the effects of a productivity shock in the sector at the origin of the creation of the new final goods in the home country on the employment levels of both countries. Here, the effect of this shock on home employment is as follows:

$$\frac{d\ell_t}{d\nu_t}\frac{1}{\ell} = \frac{1}{2}\left((1+\gamma)\left(\frac{dn_t}{d\nu_t}\frac{1}{n} + \frac{dn_t^*}{d\nu_t}\frac{1}{n^*}\right) + \frac{(\lambda-1)(2-s-s^*)}{2\lambda}\frac{d\varepsilon_t}{d\nu_t} - 1\right). \quad (121)$$

As shown in Eq.(121), the effect of this shock on home employment can be separated into three channels: the global number of final goods firms, the nominal exchange rate, and the constant term. The first channel is positive, but both the second and the third channels are negative. Therefore, the overall effect of this shock is ambiguous.[29] Here, when $s = s^*$, the overall effect of this shock is negative. In addition, under such a circumstance, the rise in s weakens the decrease in home employment. This can be explained by the decline in the degree of the decrease in the second channel due to the rise in this value.

The effect of a productivity shock in the sector at the origin of the creation of the new final goods in the home country on foreign employment is as follows:

$$\frac{d\ell_t^*}{d\nu_t}\frac{1}{\ell^*} = \frac{1}{2}\left((1+\gamma)\left(\frac{dn_t}{d\nu_t}\frac{1}{n} + \frac{dn_t^*}{d\nu_t}\frac{1}{n^*}\right) - \frac{(\lambda-1)(2-s-s^*)}{2\lambda}\frac{d\varepsilon_t}{d\nu_t} - 1\right). \quad (122)$$

Again, there are three channels: the global number of final goods firms, the nominal exchange rate, and the constant term. Both the first and the second channels are positive, but the third channel is negative. Therefore, the overall effect of this shock is also ambiguous. Here, when $s = s^*$, the overall

[29] The transmission channels of a productivity shock in the sector at the origin of the creation of the new final goods in the home country on home employment are about the same as those of a productivity shock in the home final goods sector on home employment.

effect of this shock is positive. In addition, under such a circumstance, the rise in s weakens the increase in foreign employment. This can be explained by the decline in the degree of the increase in the second channel due to the rise in this value.

4 Welfare

In this section, we examine the effects of a home monetary shock and the two types of home productivity shocks on the welfare of both countries. For simplicity, we examine only scenario (i). Following Obstfeld and Rogoff (1995, 1996) and others, we focus on the real parts of a household's utility and assume that the effect of real balances on utility is small enough to be neglected.[30] By taking the first-order approximation of the household's utility under such an assumption, we examine the effects of these shocks on the welfare of both countries. As with the analysis of the effects of these shocks on the macroeconomic variables, we examine the effects of these shocks by focusing on the degree of LCP. However, it is difficult to evaluate fully the effects of these shocks from the perspective of analytical investigation. Therefore, we numerically examine the effects of these shocks. To perform analyses based on the numerical example, we need to specify values of five parameters. To begin with, we set the elasticity of substitution between any two differentiated final goods at $\lambda = 10$, since final goods tend to be highly substitutable, and thus the elasticity among them tends to be high. On the other hand, we set the elasticity of substitution between any two differentiated intermediate inputs at $\sigma = 3$, since intermediate inputs tend to be highly differentiated, and thus the elasticity among them tends to be low. The values of these elasticities are basically based on the idea of Shioji (2006).[31] Next, following Erceg et al. (2000), we set the elasticity of substitution among labor varieties at $\xi = 6$. Finally, we set γ and δ somewhat

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[30]By abstracting from the utility of real balances, we follow the formulation of Obstfeld and Rogoff (1995, 1996). Many literatures of NOEM model use this formulation; see, for example, Betts and Devereux (2000), Corsetti et al. (2000), Obstfeld and Rogoff (2000, 2002), Tille (2001), Sutherland (2004), Corsetti and Pesenti (2005), Berger (2006), Shi and Xu (2007), and Dohwa (2008, 2014).

[31]In Shioji (2006), goods are classified into three "types," called "high-tech tradables," "low-tech tradables," and "non-tradables." He argues that high-tech goods tend to be highly differentiated, and thus the within-type elasticity tends to be low, while low-tech goods and non-tradables are highly substitute with the other goods of the same type.

arbitrarily at 1 and 0.5, respectively. In what follows, we describe the closed form solutions that show the effects of three types of shocks on the welfare of both countries. After introducing some speculations from the perspective of analytical investigation, we show the numerical example described above.

4.1 Analytical investigation

4.1.1 Monetary shock

The effects of a home monetary shock on the welfare of both countries are as follows:

$$\frac{dU_t}{d\mu_t} = 1 - \frac{dP_t}{d\mu_t}\frac{1}{P} - \kappa\ell\frac{d\ell_t}{d\mu_t}\frac{1}{\ell}, \tag{123}$$

$$\frac{dU_t^*}{d\mu_t} = -\frac{dP_t^*}{d\mu_t}\frac{1}{P^*} - \kappa\ell^*\frac{d\ell_t^*}{d\mu_t}\frac{1}{\ell^*}. \tag{124}$$

From Eqs.(123) and (124), the effects of this shock on the welfare of both countries are basically ambiguous. Therefore, we consider under what circumstances a home monetary shock raises or does not raise the levels of home and foreign welfare. To begin with, it follows from Eqs.(93), (94), (95), (99), (101) and (123) that a home monetary shock raises home welfare as long as s and s^* meet the following condition:

$$\begin{aligned}&\Big[\Gamma(\Xi - \lambda\Phi) - \gamma(1-\delta)\{\Omega - (2\lambda - 1)\Phi\}\Big]s \\ > -&\Big[\Gamma(\Xi - \lambda\Phi) + \gamma(1-\delta)(\Omega - \Phi)\Big]s^* - 2\gamma(1-\delta)\{\Omega - (2\lambda - 1)\Phi\},\end{aligned} \tag{125}$$

where $\Gamma \equiv (\lambda-1)\{1+\delta+\gamma(1-\delta)\}+(1+\delta) > 0$, $\Xi \equiv \sigma\xi\lambda\{2(\lambda-1)(1+\gamma)+1\} > 0$, $\Phi \equiv (\sigma-1)(\xi-1)(\lambda-1)(1+\gamma) > 0$ and $\Omega \equiv \sigma\xi\lambda\{1+(\lambda-1)(1+\gamma)\} > 0$. Similarly, from Eqs.(93), (94), (95), (100), (102) and (124), a home monetary shock raises foreign welfare when s and s^* satisfy the following condition:

$$\begin{aligned}&\Big[\Gamma\lambda(\sigma\xi - \Phi) - \gamma(1-\delta)(\Omega - \Phi)\Big]s \\ > -&\Big[\Gamma\lambda(\sigma\xi - \Phi) + \gamma(1-\delta)\{\Omega - (2\lambda - 1)\Phi\}\Big]s^* - 2\gamma(1-\delta)(\Omega - \Phi).\end{aligned} \tag{126}$$

For example, when $s = s^* = 0$, the condition of (126) is satisfied for all reasonable values of λ, σ, ξ, γ and δ. Therefore, in this scenario, a home monetary shock can be regarded as a prosper-thy-neighbor policy in the sense that it raises foreign welfare. From the perspective of the effects of this shock on macroeconomic variables, the reason why this result is obtained is that when $s = s^*$, the increase in foreign consumption is maximized at $s = s^* = 0$, but the increase in foreign employment is minimized at $s = s^* = 0$.

4.1.2 Productivity shocks

The effects of the two types of home productivity shocks on the welfare of both countries are as follows:

$$\frac{dU_t}{d\theta_t} = -\frac{dP_t}{d\theta_t}\frac{1}{P} - \kappa\ell\frac{d\ell_t}{d\theta_t}\frac{1}{\ell}, \tag{127}$$

$$\frac{dU_t^*}{d\theta_t} = -\frac{dP_t^*}{d\theta_t}\frac{1}{P^*} - \kappa\ell^*\frac{d\ell_t^*}{d\theta_t}\frac{1}{\ell^*}, \tag{128}$$

$$\frac{dU_t}{d\nu_t} = -\frac{dP_t}{d\nu_t}\frac{1}{P} - \kappa\ell\frac{d\ell_t}{d\nu_t}\frac{1}{\ell}, \tag{129}$$

$$\frac{dU_t^*}{d\nu_t} = -\frac{dP_t^*}{d\nu_t}\frac{1}{P^*} - \kappa\ell^*\frac{d\ell_t^*}{d\nu_t}\frac{1}{\ell^*}. \tag{130}$$

As with the results shown in Eqs.(123) and (124), all of Eqs.(127), (128), (129) and (130) show that the effects of these shocks on the welfare of both countries are basically ambiguous. Therefore, we also consider under what circumstances these shocks raise or do not raise the levels of home and foreign welfare. To begin with, with regard to a productivity shock in the home final goods sector, it follows from Eqs.(103), (104), (105), (109), (111) and (127) that this productivity shock raises home welfare as long as s and s^* meet the following condition:

$$\begin{aligned}&\Big[\sigma\xi\lambda(1+\gamma)\Gamma+\{1+\delta+\gamma(1-\delta)\}\{\Omega-(2\lambda-1)\Phi\}\Big]s > -\Big[\sigma\xi\lambda(1+\gamma)\Gamma-\{1+\delta+\gamma(1-\delta)\}(\Omega-\Phi)\Big]s^* \\ &\quad -2\Big[\{\Gamma-(1+\delta)\}\{\sigma\xi\lambda(1+\gamma)+\Phi\}+\sigma\xi\lambda\gamma(1+\gamma)(1-\delta)\Big]. \end{aligned} \tag{131}$$

Similarly, from Eqs.(103), (104), (105), (110), (112) and (128), this productivity shock raises foreign welfare when s and s^* satisfy the following condition:

$$\Big[\sigma\xi\lambda(1+\gamma)\Gamma+\{1+\delta+\gamma(1-\delta)\}(\Omega-\Phi)\Big]s > -\Big[\sigma\xi\lambda(1+\gamma)\Gamma-\{1+\delta+\gamma(1-\delta)\}\{\Omega-(2\lambda-1)\Phi\}\Big]s^*$$

$$+2\left[\{\Gamma-(1+\delta)\}\{\sigma\xi\lambda(1+\gamma)+\Phi\}-\sigma\xi\lambda\gamma(1+\gamma)(1-\delta)\right]. \qquad (132)$$

When $s = s^* = 1$, we can show that this productivity shock raises the levels of home and foreign welfare, since the conditions of both (131) and (132) are satisfied for all reasonable values of λ, σ, ξ, γ and δ. In this scenario, the effects of this productivity shock on the welfare of both countries are as follows:

$$\frac{dU_t}{d\theta_t} = \frac{2\lambda-1}{2\lambda} > \frac{dU_t^*}{d\theta_t} = \frac{1}{2\lambda}. \qquad (133)$$

We can explain Eq.(133) as follows. When a productivity shock in the home final goods sector rises, there are no effects of this productivity shock on the employment levels of either country, but the effects of it on the CPIs of both countries are negative. In addition, the degree of the decrease in home CPI due to this shock exceeds the degree of the decrease in foreign CPI due to the same. Thus, the effect of this productivity shock on home welfare exceeds that on foreign welfare. On the other hand, when $s = s^* = 0$, we can show that this productivity shock certainly raises home welfare, since the condition of (131) is satisfied for all reasonable values of the five parameters described above. From the perspective of the effects of this shock on macroeconomic variables, the reason why this result is obtained is that when $s = s^*$, both the increase in home consumption and the decrease in home employment are maximized at $s = s^* = 0$.

Next, with regard to a productivity shock in the sector at the origin of the creation of the new final goods in the home country, it follows from Eqs.(113), (114), (115), (119), (121) and (129) that this productivity shock raises home welfare as long as s and s^* meet the following condition:

$$\left[\sigma\xi\lambda\Gamma+(1+\delta)\{\Omega-(2\lambda-1)\Phi\}\right]s > -\left[\sigma\xi\lambda\Gamma-(1+\delta)(\Omega-\Phi)\right]s^*$$

$$-2\left[\sigma\xi\lambda\{\gamma(1-\delta)+(\lambda-1)(1+\gamma)(1+\delta)\}+(\lambda-1)(1+\delta)\Phi\right]. \qquad (134)$$

Similarly, from Eqs.(113), (114), (115), (120), (122) and (130), this productivity shock raises foreign welfare when s and s^* satisfy the following condition:

$$\left[\sigma\xi\lambda\Gamma+(1+\delta)(\Omega-\Phi)\right]s > -\left[\sigma\xi\lambda\Gamma-(1+\delta)\{\Omega-(2\lambda-1)\Phi\}\right]s^*$$

$$-2\left[\sigma\xi\lambda\{\gamma(1-\delta)-(\lambda-1)(1+\gamma)(1+\delta)\}-(\lambda-1)(1+\delta)\Phi\right]. \tag{135}$$

From Eqs.(134) and (135), when $s = s^* = 1$, we can show that the effect of this productivity shock on home welfare is positive, while that on foreign welfare is ambiguous. In this scenario, the effects of this productivity shock on the welfare of both countries are as follows:

$$\frac{dU_t}{d\nu_t} = \frac{1}{2(\lambda-1)(1+\gamma)}\left[1+\frac{(\lambda-1)(1+\gamma)(1+\delta)}{\lambda\{1+\delta+\gamma(1-\delta)\}}\right]$$
$$> \frac{dU_t^*}{d\nu_t} = \frac{1}{2(\lambda-1)(1+\gamma)}\left[1-\frac{(\lambda-1)(1+\gamma)(1+\delta)}{\lambda\{1+\delta+\gamma(1-\delta)\}}\right]. \tag{136}$$

We can explain Eq.(136) as follows. As with the results obtained from Eq.(133), there are no effects of this productivity shock on the employment levels of both countries either. However, unlike in the case of Eq.(133), the effect of this productivity shock on home CPI is negative, but the effect of it on foreign CPI is ambiguous. Even if the effect of this productivity shock on foreign CPI is negative, the negative effect of it on home CPI exceeds that on foreign CPI. Thus, the effect of this productivity shock on home welfare exceeds that on foreign welfare. On the other hand, when $s = s^* = 0$, we can also show that this productivity shock certainly raises home welfare, since the condition of (134) is satisfied for all reasonable values of the five parameters described above. The explanation for this result based on the perspective of the effects of this shock on home macroeconomic variables is the same as that for the above referenced result based on the perspective of the effects of a productivity shock in the home final goods sector on home macroeconomic variables.

4.2 Numerical examples

4.2.1 Monetary shock

[Insert Table 1]

In this subsubsection, we examine the effects of a home monetary shock from the perspective of numerical examples. Before examining the effects of this shock on the welfare of both countries, we examine the effects of this shock on the overall consumptions of both countries (C_t and C_t^*) and the employment levels of both countries (ℓ_t and ℓ_t^*). These analyses adopt scenario (a) in Table 1 as the benchmark scenario. To begin with, the first and second lines of Table 1 show the effect of a home monetary shock on C_t and C_t^*, respectively. In all scenarios in Table 1, the effects of this shock on both C_t and C_t^* are positive. In addition, the effect of this shock on C_t in scenarios (b)$-$(d) in Table 1 is about twice that under the benchmark scenario, but the effect of this shock on C_t^* in scenarios (b)$-$(d) in Table 1 is about 1/10 that under the benchmark scenario. Next, the third and fourth lines of Table 1 show the effect of a home monetary shock on ℓ_t and ℓ_t^*, respectively. In all scenarios in Table 1, the effects of this shock on both ℓ_t and ℓ_t^* are also positive. In addition, the effect of this shock on ℓ_t in scenarios (b)$-$(d) in Table 1 is about 1/2 that under the benchmark scenario, but the effect of this shock on ℓ_t^* in scenarios (b)$-$(d) in Table 1 is about decuple that under the benchmark scenario.

We now examine the effects of a home monetary shock on the welfare of both countries. The fifth and sixth lines of Table 1 show the effect of a home monetary shock on the home country's utility and that on the foreign country's utility, respectively. In scenarios (b)$-$(d) in Table 1, which are scenarios other than the benchmark scenario, the effect of this shock on the home country's utility is positive, but that on the foreign country's utility is negative. Therefore, scenarios (b)$-$(d) in Table 1 show that a home monetary shock has a prosper-thyself and beggar-thy-neighbor effect. This can be explained based on the results that s and s^* satisfy the condition (125), while s and s^* fail to fulfill the condition (126). In addition, compared with the benchmark scenario, the effect of this shock on the home country's utility strengthens in scenarios (b)$-$(d) in Table 1, but that on the foreign country's utility weakens in the same scenarios.

4.2.2 Productivity shocks

[Insert Table 2]

In this subsubsection, we examine the effects of the two types of home productivity shocks from the perspective of numerical examples. Before examining the effects of these shocks on the welfare of both countries, we examine the effects of these shocks on C_t and C_t^*, and ℓ_t and ℓ_t^*. These analyses also adopt scenario (a) in Table 2 as the benchmark scenario. To begin with, the first and second lines of Table 2 show the effect of a productivity shock in the home final goods sector on C_t and C_t^*, respectively. In all scenarios in Table 2, the effect of this shock on C_t is positive. On the other hand, in scenarios other than scenarios (b) and (d) in Table 2, the effect of this shock on C_t^* is negative. In scenario (a) in Table 2, the positive and negative effects are largest, since all of the intermediate goods firms employ PCP. When the degree of LCP rises, these effects are significantly weakened compared with the benchmark scenario. The seventh and eighth lines of Table 2 show the effect of a productivity shock in the sector at the origin of the creation of the new final goods in the home country on C_t and C_t^*, respectively. In all scenarios in Table 2, the effects of this shock on C_t and C_t^* are positive and negative, respectively. As with the analysis of the former productivity shock, in scenario (a) in Table 2, the positive and negative effects are the largest, since all of the intermediate goods firms employ PCP. When the degree of LCP rises, these effects are also significantly weakened compared with the benchmark scenario. Next, the third and fourth lines of Table 2 show the effect of a productivity shock in the home final goods sector on ℓ_t and ℓ_t^*, respectively. In scenarios other than scenario (b) in Table 2, the effect of this shock on ℓ_t is non-positive. On the other hand, in scenarios other than scenario (c) in Table 2, the effect of this shock on ℓ_t^* is non-negative. In scenario (a) in Table 2, the positive and negative effects are the largest, since all of the intermediate goods firms employ PCP. When the degree of LCP rises, these effects are significantly weakened compared with the benchmark scenario. The ninth and tenth lines of Table 2 show the effect of a productivity shock in the sector at the origin of the creation of the new final goods in the home country on ℓ_t and ℓ_t^*, respectively. In scenarios other than scenario (b) in Table 2, the effect of this shock on ℓ_t is non-positive. On the other hand, in scenarios other than scenario (c) in Table 2, the effect of this shock on ℓ_t^* is non-negative. As with the analysis of the former productivity shock, in scenario (a) in Table 2, the positive and negative effects are largest, since all of the intermediate goods firms employ PCP. When the degree of LCP rises, these effects are also significantly weakened compared with the benchmark scenario.

We now examine the effects of the two types of home productivity shocks on the welfare of both countries. The fifth and sixth lines of Table 2 show the effect of a productivity shock in the home final goods sector on the home country's utility and that on the foreign country's utility, respectively. In scenarios $(a)-(c)$ in Table 2, the effect of this shock on the home country's utility is positive, but that on the foreign country's utility is negative. This can be explained based on the results that s and s^* satisfy the condition (131), but s and s^* fail to fulfill the condition (132). In addition, compared with the benchmark scenario, the effect of this shock on the home country's utility weakens in scenarios $(b)-(d)$ in Table 2, but that on the foreign country's utility strengthens in the same scenarios. The eleventh and twelfth lines of Table 2 show the effect of a productivity shock in the sector at the origin of the creation of the new final goods in the home country on the home country's utility and that on the foreign country's utility, respectively. As with the analysis of the former productivity shock, in scenarios $(a)-(c)$ in Table 2, the effect of this shock on the home country's utility is positive, but that on the foreign country's utility is negative. This can be explained based on the results that s and s^* satisfy the condition (134), but s and s^* fail to fulfill the condition (135). In addition, compared with the benchmark scenario, the effect of this shock on the home country's utility also weakens in scenarios $(b)-(d)$ in Table 2, but that on the foreign country's utility also strengthens in the same scenarios.

5 Conclusions

By incorporating the three factors of LCP, vertical production and trade, and endogenous number of final goods firms into the standard NOEM model, this paper has examined how a home monetary shock and the two types of home productivity shocks affect the macroeconomic variables and welfare. The main findings of this paper can be summarized as follows. First, we show that a rise in the degree of LCP magnifies the degree of the response of the nominal exchange rate caused by each of the three types of shocks originating in the home country. To be more precise, a rise in the degree of LCP weakens the depreciation of the nominal exchange rate caused by a home monetary shock and the appreciation of the nominal exchange rate caused by each of the two types of home productivity shocks. Second, we show that each of the three types of shocks has an effect on the number of final goods firms located in the home and foreign countries, and this effect depends on the degree of LCP. Third, the welfare effects of a home monetary shock have very similar aspects to those shown in the standard NOEM model. For example, when the degree of LCP rises, a home monetary shock has a beggar-thy-neighbor effect. This aspect is basically the same as that shown in the standard NOEM model. However, when the degrees of both countries'

LCPs are zero, a home monetary shock has no effect on home welfare. This is a novel feature of the analysis in this paper. Finally, the welfare effects of a productivity shock in the home final goods sector have a number of the same aspects as those of a productivity shock in the sector at the origin of the creation of the new final goods in the home country. For example, the effects of the two types of home productivity shocks on home welfare are positive, regardless of the degrees of either country's LCP. In addition, under circumstances other than full LCP, the effects of these shocks on foreign welfare are negative. However, under a circumstance of full LCP, the effect of the former productivity shock on foreign welfare is positive, but that of the latter productivity shock on foreign welfare is negative. This depends on the difference between the effects of these shocks on overall foreign consumption.

In this paper, we obtained the above findings by making some strong assumptions. It would be more desirable to find the various results by relaxing these assumptions. For example, in this paper, the intermediate goods firms are supposed to set their export prices in either PCP or LCP. However, as mentioned in Dohwa (2014), a third country's currency plays an important role in today's trade. It is often observed that, even where the U.S. is not involved, a large percentage of transactions are invoiced in U.S. dollar, which is handled as "third country currency" in such transactions. To capture such an aspect, it would be necessary to build a new kind of NOEM model. In future work, we intend to examine the possibility of incorporating "third country currency" into this kind of NOEM model. Another important future task would be to incorporate FDI into this paper's framework. The tremendous growth in FDI flows has changed the trade structure of the global economy. More precisely, it is often observed that the growth in FDI establishes vertical production and trade in the global economy. Although we incorporated only the vertical structure of production and trade into this paper's framework, it would be worth modeling the relationship between FDI and vertical production and trade in this kind of NOEM model. By allowing for extentions such as the above, the results of model analyses would be rich enough to evaluate the welfare effects of monetary and productivity shocks.

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Table 1: The effects of a home monetary shock.

	$(a)\ s = s^* = 0$	$(b)\ s = 1,\ s^* = 0$	$(c)\ s = 0,\ s^* = 1$	$(d)\ s = s^* = 1$
$\frac{dC_t}{d\mu_t}\frac{1}{C}$	0.528	0.991	1.016	1.015
$\frac{dC_t^*}{d\mu_t}\frac{1}{C^*}$	0.528	0.039	0.065	0.040
$\frac{d\ell_t}{d\mu_t}\frac{1}{\ell}$	0.950	0.499	0.523	0.500
$\frac{d\ell_t^*}{d\mu_t}\frac{1}{\ell^*}$	0.050	0.477	0.501	0.500
$\frac{dU_t}{d\mu_t}$	0.000	0.713	0.726	0.738
$\frac{dU_t^*}{d\mu_t}$	0.500	-0.226	-0.213	-0.238

Table 2: The effects of the two types of home productivity shocks.

	$(a)\ s = s^* = 0$	$(b)\ s = 1,\ s^* = 0$	$(c)\ s = 0,\ s^* = 1$	$(d)\ s = s^* = 1$
$\frac{dC_t}{d\theta_t}\frac{1}{C}$	18.500	1.841	0.915	0.950
$\frac{dC_t^*}{d\theta_t}\frac{1}{C^*}$	−17.500	0.085	−0.841	0.050
$\frac{d\ell_t}{d\theta_t}\frac{1}{\ell}$	−16.200	0.044	−0.834	0.000
$\frac{d\ell_t^*}{d\theta_t}\frac{1}{\ell^*}$	16.200	0.834	−0.044	0.000
$\frac{dU_t}{d\theta_t}$	27.500	1.817	1.378	0.950
$\frac{dU_t^*}{d\theta_t}$	−26.500	−0.378	−0.817	0.050
$\frac{dC_t}{d\nu_t}\frac{1}{C}$	1.528	0.140	0.062	0.065
$\frac{dC_t^*}{d\nu_t}\frac{1}{C^*}$	−1.472	−0.007	−0.084	−0.010
$\frac{d\ell_t}{d\nu_t}\frac{1}{\ell}$	−1.350	0.004	−0.070	0.000
$\frac{d\ell_t^*}{d\nu_t}\frac{1}{\ell^*}$	1.350	0.070	−0.004	0.000
$\frac{dU_t}{d\nu_t}$	2.278	0.138	0.101	0.065
$\frac{dU_t^*}{d\nu_t}$	−2.222	−0.045	−0.082	−0.010

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