The role of local currency pricing in the international transmission effects of a government spending shock in an economy with vertical production linkage and foreign direct investment

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May 2022

Discussion Paper No. 2210

GRADUATE SCHOOL OF ECONOMICS

KOBE UNIVERSITY

ROKKO, KOBE, JAPAN

The role of local currency pricing in the international transmission effects of a government spending shock in an economy with vertical production linkage and foreign direct investment

Kohjiro Dohwa*†

Abstract

By constructing a two-country model with asymmetry in price-setting behavior between home and foreign intermediate goods firms, vertical production and trade, and endogenous entry of three types of final goods firms, this paper examines the effects of a home government spending shock. In particular, it focuses on the role of asymmetry in price-setting behavior between home and foreign intermediate goods firms. A home government spending shock is shown to result in the entry of multinational firms from both countries, an increase in the aggregate outputs of both countries, a deterioration in home welfare, and an improvement in foreign welfare. In addition, with an increase in the ratio of home and/or foreign intermediate goods firms setting their export prices in the local currency, the effects of this shock on the entry of home multinational firms, the increase in aggregate foreign output, the deterioration in home welfare and the improvement in foreign welfare are shown to be weakened, while the effects of this shock on the entry of foreign multinational firms and the increase in aggregate home output are intensified.

Keywords: Local currency pricing, Vertical production and trade, Firm entry, Foreign direct investment, Government spending shock

JEL Classification: F41, F42

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1 Introduction

Developed countries have been increasing their outward foreign direct investment (hereafter, outward FDI) over the past 30 years or more. As Fig.1 shows, the U.S. has been increasing its outward FDI the most rapidly by far, while Japan's outward FDI has been increasing rapidly since the 2010s. Meanwhile, as Fig.2 shows, inward foreign direct investment (hereafter, inward FDI) has also been increasing in developed countries with the exception of Japan. One of the purposes of this paper, therefore, is to examine the macroeconomic effects of firm entry, including from outward and inward FDI.

[Insert Fig.1 around here]

[Insert Fig.2 around here]

Moreover, trade structures have been changing over the past few decades. A vertical trade structure has prevailed in trade between Japan and Asia, for instance. This means that in the current trade between Japan and China, intermediate goods produced in Japan are exported to China, where they are assembled into final goods, which are then sold in China or exported to Japan and the U.S. This type of trade structure is not limited to between Japan and China, but has become the mainstream around the world. Using data from 10 OECD and four emerging economies, Hummels et al. (2001) find that it is a feature of today's global economy.[1] Another feature of current trade is that firms in many developed countries other than the U.S. are setting export prices in local currencies. In other words, they employ local currency pricing (LCP). This has been discovered by many researchers (see Marston (1990), Knetter (1993), Parsley (1993), Athukorala and Menon (1994), ECU Institute (1995), Gagnon and Knetter (1995), and Gopinath and Rigobon (2008), for instance). Data from Japan's Ministry of Finance also shows that the ratio of Japanese firms exporting to the U.S. that set export prices in local currency (LCP firms) is high at about 90 percent (2001 Jan-Jun: 87.4 percent, 2020 Jul-Dec: 87.4 percent), while the ratio of Japanese LCP firms exporting to the EU is low but increasing year by year with the ratio exceeding 50 percent in 2020 (2001 Jan-Jun: 42.6 percent, 2020 Jul-Dec: 55.8 percent). Further the data shows that the ratio of LCP firms exporting from the EU to Japan mirrors the ratio of LCP firms exporting from Japan to the EU in terms of the trend (2001 Jan-Jun: 48.1 percent, 2020 Jul-Dec: 57.1 percent). On the other hand, while the ratio of LCP firms exporting from the U.S. to Japan is low, it has increased slightly in recent years (2001 Jan-Jun: 20.5 percent, 2020 Jul-Dec: 25.6 percent).

Despite the above characteristics of global goods markets, few researchers have theoretically examined the international transmission effects of government spending by taking into account all or some of these factors. In many developed countries, government spending has played a major role in underpinning the economy following the collapse of Lehman Brothers, when monetary policy was constrained by the zero lower bound. This makes it important to examine the macroeconomic effects of a government spending shock. In recent years, there have been studies on the international transmission effects of a government spending shock by

[1] Feenstra (1998) and Yi (2003) also make the same point as Hammels et al. (2001).

the following researchers. Using the two-country New Keynesian (hereafter, NK) model in an economy where monetary policy is constrained to the zero lower bound, Cook and Devereux (2011) mainly examine the fiscal spillover effects. They show that the effect of a home government spending shock is positive on home GDP, but negative on foreign GDP. Like Cook and Devereux (2011), Fujiwara and Ueda (2013) also examine fiscal multiplier and spillover using the two-country NK model with a global liquidity trap. They show that fiscal spillovers can be both positive and negative, depending on the magnitude of the intertemporal elasticity of substitution in consumption. Additionally, they examine the fiscal spillover in an economy with LCP, showing that it becomes positive under such a circumstance. Papers by these researchers are significant in that they provide important insights into the effects of recent fiscal spending on home and foreign countries. However, they do not take into account all the characteristics of global goods markets mentioned above, though Fujiwara and Ueda (2013) do examine scenarios of both LCP and producer currency pricing (PCP), in which firms set export prices in their own currency.[2]

The paper by Johdo and Hashimoto (2005) exists as an open macroeconomic model with international firm relocation. Using a two-country model with flexible prices, they examine the effects of an increase in the corporate tax rate on consumption and welfare in both countries. However, because their model does not assume sticky prices, it is unable to examine the role of LCP. In addition, they also perform their analyses using a two-country model without vertical trade. By constructing a two-country flexible-price dynamic optimizing model with heterogeneity in firm productivity, Ghironi and Melitz (2005) examine the effects of real shocks to both aggregate productivity and entry costs on the location patterns of firms. Using model of Ghironi and Melitz (2005) in part, Corsetti et al. (2007) examine the effects of a home government spending shock on macroeconomic variables and welfare. By incorporating free entry conditions into the model, they examine these effects through the entry and exit of firms. However, despite constructing a framework that allows them to analyze firm entry and exit in an open macroeconomic model different from the model of Johdo and Hashimoto (2005), they also fail to incorporate the characteristics of recent global goods markets. Similarly, using the model of Ghironi and Melitz (2005) in part, Corsetti et al. (2013) examine the effects of a transfer from home to foreign countries. And again, despite using a model with useful features in that it deals with the firm entry of two types of tradable goods firms and one type of non-tradable goods firm, they too fail to take into account the characteristics of recent global goods markets. In particular, they are unable to address the role of LCP because their analysis is not based on the NOEM model, which originally assumed sticky prices. Using an Obstfeld and Rogoff (1995, 1996) type new open economy macroeconomics (hereafter, NOEM) model with LCP and FDI, Cavallari (2010) examines the effects of monetary and productivity shocks on macroeconomic variables. She shows that endogenous fluctuations in firms, including multinational firms, amplify spillovers on consumption and employment in the two countries. However, she examines this in a model without vertical trade. By incorporating

[2]Clancy et al. (2016) and Boug et al. (2023) also examine the macroeconomic effects of a government spending shock occurring in one small open economy. However, they do not take into account the characteristics of recent global goods markets mentioned above.

only the factor of international firm mobility into the model of Obstfeld and Rogoff (1995, 1996), Johdo (2019) examines the effects of a government spending shock on consumption and nominal exchange rates. He shows that firm mobility weakens the effects of this shock on relative consumption and nominal exchange rates.[3][4][5] As can be seen from the above studies, there are many open macroeconomic models that deal with firm entry, including FDI. However, despite the fact that significant FDI has been observed in the real economy, and that demand promotion policies may attract inward FDI, few of them deal with the relationship between FDI and a government spending shock.

Studies by the following researchers exist with regard to vertical production and trade in open macroeconomic models. Using the stochastic two-country NOEM model of the Obstfeld and Rogoff (1995, 1996) type, Huang and Liu (2006) examine the effects of a home monetary shock on the welfare of both countries. They show that not only in the case of PCP but also in the case of LCP, an increase in the stage of production and trade tends to make a home monetary shock profitable for both home and foreign countries. By incorporating staggered price-setting mainly into the Huang and Liu (2006) model, Huang and Liu (2007) examine international business cycles driven by monetary shocks. They find that this model performs much better than a single-stage model without vertical trade. Shi and Xu (2007) examine the issue of non-cooperative optimal monetary policy in an economy with vertical production and trade by incorporating two stages of production and trade into the stochastic two-country NOEM model. They examine the issue by assuming either PCP or LCP for intermediate goods firms. Gong et al. (2016) examine the issue of optimal monetary policy using a two-country NK model with two stages of production and trade. They examine the issue by assuming PCP in both intermediate and final goods trade. Wei and Xie (2020) examine the issue of optimal monetary policy using a small open economy NK model with multiple stages of production and trade. They show that a more desirable rule would be to target separate producer price inflation in different stages of production. Devereux et al. (2020) examine the effects of government spending shocks using a multi-country model with international production networks. They show that network structures play a major role in fiscal spillover effects when sticky wages are assumed in the model. Although the above studies other than the one by Devereux et al. (2020) are associated with the design and effects of monetary policy, they are very significant because they provide insights into the importance of a number of stages of production and trade. The study by Devereux et al. (2020) is also interesting in that it uses numerical analysis for a model with a large number of production structures and examines the fiscal spillover effects on the Eurozone of a government spending shock in Germany with and

[3]This paper refers to the model that adopts a one-period-ahead price setting similar to the Obstfeld and Rogoff (1995, 1996) model as the NOEM model with respect to the nominal rigidities. On the other hand, the model that adopts staggered price setting similar to the Calvo (1983) model is referred to as the New Keynesian model.

[4]Other related studies using the NOEM model include those by Caselli (2001), Lombardo and Sutherland (2004), Pierdzioch (2004), Chu (2005), Ganelli (2003, 2005a, 2005b), and Ganelli and Tervala (2010). However, these researchers use two-country models without firm entry.

[5]A non-exhaustive list of the literature on firm entry, including outward FDI, is Corsetti et al. (2004), Lewis (2006), Bilbiie et al. (2007), Russ (2007), Bergin and Corsetti (2008), Cavallari (2013), and Johdo (2013, 2015).

without a network structure. Their model points to the importance of using a macroeconomic model with production linkages across countries to examine the international transmission effects of a government spending shock. However, None of these studies do not deal with the role of firm entry.

The purpose of this paper is to examine the effects of a government spending shock on macroeconomic variables and welfare using a two-country model that takes into account three features of global goods markets.[6] Specifically, by incorporating the factor of LCP for home and foreign firms engaged in intermediate goods trade, this paper focuses its analysis on its role on the effects of a government spending shock.[7] There are many studies by researchers on the price-setting behavior of firms. Betts and Devereux (2000) were the first to introduce LCP into the two-country NOEM model to examine the effects of a country's government spending shock on the welfare of both countries. However, they assume that the fraction of exporters who set prices in local currency of sale is symmetric across countries. By incorporating the assumption of LCP adopted by Betts and Devereux (2000) into the model of Obstfeld and Rogoff (1995, 1996), Carré and Collard (2003) examine whether Europe should implement monetary union from the perspective of welfare effects in accordance with a permanent government spending shock in the home country. They show that home households will benefit more from a transition to monetary union when the degree of LCP rises. By incorporating firms' asymmetric price-setting behavior into the model of Corsetti and Pesenti (2001), which is a typical NOEM model, Michaelis (2006) examines the effects of a home monetary shock on the welfare of both countries. He considers how the effects of a home monetary shock on the welfare of both countries changes based on the fraction of LCP firms. By incorporating asymmetric price-setting behavior by firms and two stages of production and trade into the model of Corsetti and Pesenti (2001), Dohwa (2014) examines the effects of a home monetary shock on the welfare of both countries. He incorporates the former factor for home and foreign firms engaged in trade in intermediate goods. With the exception of Cavallari (2010), none of the models presented in the previous paragraphs that factor in LCP take into account the existence of both PCP firms and LCP firms. They assume that all firms employ LCP. Devereux and Yu (2019) examine the fiscal spillover effects using a two-country NK model. They do examine both PCP and LCP scenarios, but in the latter scenario, they assume that all firms employ LCP. As can be seen from the above examples, not many studies examine the effects

[6]Dohwa (2018) examines the effects of home corporate tax reduction by considering three characteristics of global goods markets. The model in the current paper is based on that of Dohwa (2018).

[7]The NOEM model with the element of LCP was constructed by Betts and Devereux (2000) and Devereux and Engel (2003) based on the evidence that the law of one price does not hold. The NOEM model with this element assumes that prices are sticky in the currency of the destination market. The incorporation of this assumption results in a reduction in the terms of trade as the price of imports relative to exports is reduced when the nominal exchange rate depreciates. By contrast, Gopinath et al. (2020) proposed a dominant currency paradigm (DCP) approach, based on observations such as the reason the majority of trade is set in a few dominant currencies (often the US dollar). Under DCP, firms set export prices in the dominant currency, which is characterized by the fact that firms do not change it frequently. In addition, terms of trade are stable under DCP, which is derived from the pricing of imports and exports in the common currency and the low sensitivity of these prices to changes in the nominal exchange rate. This result for terms of trade under DCP can be contrasted with the result for it under LCP.

of a government spending shock taking both PCP and LCP firms into account in their model.

In this paper, we intend to incorporate into our model the existence of two types of tradable goods firms and one type of non-tradable goods firm. In order to do so, taking into account the characteristics of recent global goods markets, we extend the two-country flexible price model of Corsetti et al. (2013) to create a two-country NOEM model. Additionally, as in the studies by Michaelis (2006) and Dohwa (2014), this paper considers both PCP and LCP firms and assumes a different fraction of these firms in home and foreign countries. To summarize, this paper contributes to the literature by constructing a two-country NOEM model that incorporates firm entry, including FDI, a vertical structure of production and trade, and asymmetric price-setting behavior between home and foreign firms engaged in intermediate goods trade, and then showing how it can be used to solve issues that cannot be addressed using more conventional models, such as the international transmission effects of a government spending shock in the new framework and the role of LCP in how this shock impacts macroeconomic variables and welfare.

The main results of this paper are as follows. In an economy with sticky prices, a positive home government spending shock causes a trade deficit in the home country through higher imports, which in turn depreciates the nominal exchange rate to balance it. This nominal exchange rate depreciation affects the profits and entry costs of final goods firms, causing the number of these firms to fluctuate. The number of home-located final goods firms, including foreign multinational firms, increases as entry costs increase, but profits increase even more. The reason for the increase in entry costs for these firms is that nominal exchange rate depreciation increases the home-currency prices of intermediate goods imported from abroad; and the reason for the increase in their profits is that nominal exchange rate depreciation causes a demand shift from foreign final goods to home final goods, especially among domestic market and export firms. Similarly, the number of foreign-located final goods firms, excluding domestic market firms, also essentially increases. This is because the entry costs for these firms are lower, and their profits exceed their entry costs. The reason for the lower entry costs is that nominal exchange rate depreciation lowers the foreign-currency prices of intermediate goods imported from the home country. The depreciation of the nominal exchange rate and the increase in the number of final goods firms selling in the foreign market push down the foreign price index and increase overall foreign consumption. This is because, with regard to the former, a fall in the foreign-currency prices of foreign final goods as well as imported home final goods contribute to pushing down the foreign price index, while with regard to the latter, an increase in the supply of final goods also contributes to pushing down the foreign price index. On the other hand, fluctuations in overall home consumption through fluctuations in the home price index are ambiguous. This is because an increase in the number of final goods firms selling in the home market contributes to pushing down the home price index through an increase in the supply of final goods, while nominal exchange rate depreciation increases the home-currency prices of home final goods as well as imported foreign final goods, thereby pushing up the home price index. Although the number of final goods firms in the world as a whole will increase, this will increase the demand for intermediate goods in both countries, thereby causing an increase in employment levels in both home and foreign countries. How-

ever, home employment increases at least as much as foreign employment if not more. One reason for this is that the demand for foreign intermediate goods by home final goods firms is essentially much lower in the foreign country than in the home country as a result of nominal exchange rate depreciation. As regards aggregate outputs, both aggregate home output and aggregate foreign output essentially increase. Aggregate outputs in both countries increase because a positive home government spending shock has a positive effect on the total number of final goods firms located in each country, causing an increase in the supply of final goods in each country. Having considered an economy with sticky prices, this paper goes on to examine the persistent effects of a positive home government spending shock on macroeconomic variables in an economy with flexible prices. This shock has persistent positive effects, mainly on aggregate outputs and employment levels in both countries. These are based on the fact that, even in an economy with flexible prices, an increase in the number of final goods firms increases the supply of goods with regard to aggregate output, and an increase in the number of final goods firms with regard to employment levels increases the demand for intermediate goods in both countries. The effects on the welfare of both countries are shown by the utility from consumption and the disutility from employment. Judging from the total of both economies with sticky prices and flexible prices, the welfare of the home country deteriorates and that of the foreign country improves. In particular, the deterioration in home welfare is based on lower utility from consumption and higher disutility from employment.

Finally, the present paper examines the role of LCP on the effects of this shock on short-run macroeconomic variables and welfare in both countries. We find that an increase in the degree of LCP weakens the degree of the home country's trade deficit, and therefore the degree of nominal exchange rate depreciation. This weakening of the nominal exchange rate depreciation contributes to fluctuations in the different macroeconomic variables mentioned above. In particular, an increase in the degree of LCP essentially enhances the new entry of foreign multinational firms into the home market and the increase in aggregate home output, while it essentially weakens the new entry of home multinational firms into the foreign market and the increase in aggregate foreign output. The increase in new entries of foreign multinational firms is based on a weakening of the increase in entry costs due to a weakening of the nominal exchange rate depreciation, while the weakening of new entry of home multinational firms is based on a weakening of the decrease in entry costs due to the same. Further, when the degree of LCP rises, it also weakens the deterioration in home welfare and the improvement in foreign welfare through its effects on consumption and employment in each country. Overall consumption and employment in both countries have the following characteristics. First, an increase in foreign LCP weakens (or intensifies) the decrease (or increase) in overall home consumption, while an increase in home LCP weakens the increase in overall foreign consumption. The latter results from a weakening of the decrease in foreign CPI based on a weakening of (1) the increase in the supply of final goods, (2) the decrease in the foreign-currency prices of foreign final goods, and (3) the decrease in the foreign-currency prices of imported home final goods. Second, an increase in home LCP weakens the increase in home employment, while an increase in foreign LCP intensifies the increase in foreign employment.

The remainder of this paper is structured as follows. Section 2 presents the model. Section

3 examines the effects of a home government spending shock on the macroeconomic variables of both countries. Section 4 examines the effects of a home government spending shock on the welfare of both countries. The final section summarizes the findings and concludes the paper.

2 The model

The world consists of two countries, one denoted as the home country and the other as the foreign country. The foreign variables are denoted 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 available in their respective domestic markets. Our assumption regarding vertical trade is based on that in Shi and Xu (2007). There are two types of firms in each country: final goods firms and intermediate goods firms. Final goods firms operate in either the tradable or the non-tradable goods sectors. Final tradable goods are sold in the domestic markets, making them import-competing goods, or exported. Final non-tradable goods are produced by the multinational firms in the trading partner. These firms produce differentiated final goods using a composite of domestically produced and imported intermediate inputs. On the other hand, intermediate goods firms, which are broken down into either domestic market or export firms, produce differentiated products using labor. Both final goods firms and intermediate goods firms are monopolistically competitive producers. Domestic market and export firms among the home-located final goods firms are assumed to exist continuously in the interval $[0, n_{D,t}]$ and the interval $[0, n_{X,t}]$, respectively, and that foreign multinational firms among the home-located final goods firms exist continuously in the interval $[0, n^*_{MN,t}]$, where $n_{D,t}$, $n_{X,t}$ and $n^*_{MN,t}$ are endogenous.[8] There is free entry in the final goods sector, but final goods firms face fixed entry costs to start production of a particular good.[9] Home and foreign intermediate goods are the inputs required for the formulation of entry costs. With regard to the number of intermediate goods firms in both countries, although it is assumed that domestic market and export firms exist continuously in the intervals $[0, \frac{1}{2}]$ and the interval $[\frac{1}{2}, 1]$, respectively,[10] it is also assumed that a fraction η of the export firms located in the home country and a fraction η^* of the export firms located in the foreign country set their export prices in the local currency, i.e., they employ LCP. The remaining intermediate goods firms in the export sector located in both countries set their export prices in their own currency, i.e., they employ

[8]The domestic market firms among the home-located final goods firms are indexed by $z_{F|D} \in [0, n_{D,t}]$. Similarly, the export firms among the home-located final goods firms, and the foreign multinational firms among the home-located final goods firms are indexed by $z_{F|X} \in [0, n_{X,t}]$ and $z_{F|MN} \in [0, n^*_{MN,t}]$, respectively. A similar interpretation holds for $z^*_{F|D} \in [0, n^*_{D,t}]$, $z^*_{F|X} \in [0, n^*_{X,t}]$ and $z^*_{F|MN} \in [0, n_{MN,t}]$.

[9]As defined above, although $[0, n_{D,t}]$, $[0, n_{X,t}]$ and $[0, n^*_{MN,t}]$ represent intervals for home-located final goods firms, they can be also interpreted as intervals for the goods produced by home-located final goods firms. A similar interpretation holds for $[0, n^*_{D,t}]$, $[0, n^*_{X,t}]$ and $[0, n_{MN,t}]$.

[10]The home intermediate goods firms selling in the domestic and the export markets are indexed by $z_{I|D} \in [0, \frac{1}{2}]$ and $z_{I|X} \in [\frac{1}{2}, 1]$, respectively. A similar interpretation holds for $z^*_{I|D} \in [0, \frac{1}{2}]$ and $z^*_{I|X} \in [\frac{1}{2}, 1]$.

PCP.[11] This paper assumes that final goods produced in each country are priced identically in all the periods to allow for flexible prices. It also assumes that the law of one price does not always hold for intermediate goods in all the periods.

2.1 Firms

2.1.1 Final goods firms

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

$$Y_t(z_{F|j}) = 2Y_{h,t}(z_{F|j})^{\frac{1}{2}} Y_{f,t}(z_{F|j})^{\frac{1}{2}}, \quad j = D, X, MN \tag{1}$$

where

$$Y_{h,t}(z_{F|j}) = \left(\int_0^{\frac{1}{2}} Y_{h,t}(z_{F|j}, z_{I|D})^{\frac{\sigma-1}{\sigma}} dz_{I|D} \right)^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

$$Y_{f,t}(z_{F|j}) = \left(\int_{\frac{1}{2}}^{\frac{1+\eta^*}{2}} Y_{f,t}^{LCP}(z_{F|j}, z_{I|X}^*)^{\frac{\sigma-1}{\sigma}} dz_{I|X}^* + \int_{\frac{1+\eta^*}{2}}^{1} Y_{f,t}^{PCP}(z_{F|j}, z_{I|X}^*)^{\frac{\sigma-1}{\sigma}} dz_{I|X}^* \right)^{\frac{\sigma}{\sigma-1}}. \tag{3}$$

In Eq.(1), $Y_t(z_{F|j})$ is the output produced by home-located final goods firm $z_{F|j}$ and $Y_{h,t}(z_{F|j})$ ($Y_{f,t}(z_{F|j})$) is a composite of the home (foreign) intermediate inputs used by home-located final goods firm $z_{F|j}$. $Y_{h,t}(z_{F|j})$ and $Y_{f,t}(z_{F|j})$ are given in Eqs.(2) and (3), where $Y_{h,t}(z_{F|j}, z_{I|D})$ is the home intermediate input $z_{I|D}$ used by home-located final goods firm $z_{F|j}$, $Y_{f,t}^{PCP}(z_{F|j}, z_{I|X}^*)$ ($Y_{f,t}^{LCP}(z_{F|j}, z_{I|X}^*)$) is the foreign PCP (LCP) intermediate input $z_{I|X}^*$ used by home-located final goods firm $z_{F|j}$, and $\sigma > 1$ is the elasticity of substitution between any two differentiated intermediate inputs. Based on the production functions defined above, we can define these price indexes. We can also derive the demand of each of the home- and foreign-located final goods firms for intermediate inputs required in production activities. These are summarized in Appendix A in the online appendices.

The resource constraints for each variety of goods produced by the home-located final goods firms are given as follows:

$$Y_t(z_{F|j'}) \geq \int_0^1 C_{h,t}(z_{F|j'}, x)dx + G_{h,t}(z_{F|j'}), \tag{4}$$

$$Y_t(z_{F|X}) \geq \int_0^1 C_{h,t}^*(z_{F|X}, x^*)dx^* + G_{h,t}^*(z_{F|X}), \tag{5}$$

where $j' = (D, MN)$, $C_{h,t}(z_{F|j'}, x)$ is the home household x's consumption of goods produced by the home-located final goods firm $z_{F|j'}$, $C_{h,t}^*(z_{F|X}, x^*)$ is the foreign household x^*'s consumption of goods produced by the home-located final goods firm $z_{F|X}$, $G_{h,t}(z_{F|j'})$ is the home

[11] As defined above, although $[0, \frac{1}{2}]$ represents the interval for the home and foreign intermediate goods firms sold in the domestic market, $[0, \frac{1}{2}]$ also represents the interval for the inputs produced by home and foreign intermediate goods firms selling in the domestic market. A similar interpretation holds for $[\frac{1}{2}, 1]$.

government's consumption of goods produced by the home-located final goods firm $z_{F|j'}$ and $G^*_{h,t}(z_{F|X})$ is the foreign government's consumption of goods produced by the home-located final goods firm $z_{F|X}$. Using Eqs.(4) and (5), the home-located final goods firms' profits are given as follows:

$$\Pi_{F,t}(z_{F|j'}) = (p_{h,t}(z_{F|j'}) - \Lambda_t)Y_t(z_{F|j'}), \tag{6}$$

$$\Pi_{F,t}(z_{F|X}) = (\varepsilon_t p^*_{h,t}(z_{F|X}) - \Lambda_t)Y_t(z_{F|X}), \tag{7}$$

where $p_{h,t}(z_{F|j'})$ ($p^*_{h,t}(z_{F|X})$) is the home (foreign) price, which corresponds to $Y_t(z_{F|j'})$ ($Y_t(z_{F|X})$), Λ_t is the unit cost to produce home final goods, and ε_t is the nominal exchange rate, defined as the home-currency price of the foreign currency.

To start production, each of the final goods firms must pay a fixed cost. The entry cost for each class of final goods firms is assumed to be given in the following form:

$$q_t(z_{F|j''}) = \left(\tilde{P}_{h,t} + \tilde{P}_{f,t}\right) n^{\gamma}_{j'',t}, \tag{8}$$

$$q_t(z_{F|MN}) = \left(\tilde{P}_{h,t} + \tilde{P}_{f,t}\right) n^{*\gamma}_{MN,t}, \tag{9}$$

$$q^*_t(z^*_{F|j''}) = \left(\tilde{P}^*_{h,t} + \tilde{P}^*_{f,t}\right) n^{*\gamma}_{j'',t}, \tag{10}$$

$$q^*_t(z^*_{F|MN}) = \left(\tilde{P}^*_{h,t} + \tilde{P}^*_{f,t}\right) n^{\gamma}_{MN,t}, \tag{11}$$

where $j'' = (D, X)$, $\tilde{P}_{h,t}$ ($\tilde{P}_{f,t}$) is the home price index that corresponds to $Y_{h,t}$ ($Y_{f,t}$), which is a composite of the inputs produced by domestic market (export) firms in the home (foreign) intermediate goods sector, and $\gamma > 0$ is a measure of the concavity of the cost function. For example, Eq.(8) shows that each of the firms that belongs to the home-located final goods tradable sector requires both $n^{\gamma}_{j'',t}$ units of the composite of home intermediate inputs and $n^{\gamma}_{j'',t}$ units of that of foreign intermediate inputs to create a new final good. Based on Eqs.(8)−(11), we can represent the resource constraints in home and foreign intermediate inputs used by home and foreign final goods firms. These are also summarized in Appendix A in the online appendices.

2.1.2 Intermediate goods firms

As shown in more detail below, the three types of home intermediate goods firms produce differentiated goods using a continuum of labor inputs provided by the home households:

$$Y_{h,t}(z_{I|D}) = \left(\int_0^1 \ell_t(z_{I|D}, x)^{\frac{\xi-1}{\xi}} dx\right)^{\frac{\xi}{\xi-1}},$$

$$Y^{*PCP}_{h,t}(z_{I|X}) = Y^{*LCP}_{h,t}(z_{I|X}) = \left(\int_0^1 \ell_t(z_{I|X}, x)^{\frac{\xi-1}{\xi}} dx\right)^{\frac{\xi}{\xi-1}},$$

where $Y_{h,t}(z_{I|D})$ is the output of goods produced by home intermediate goods firm $z_{I|D}$ toward three types of home-located final goods firms, $Y^{*PCP}_{h,t}(z_{I|X})$ ($Y^{*LCP}_{h,t}(z_{I|X})$) is the output

of goods produced by home PCP (LCP) intermediate goods firm $z_{I|X}$ toward three types of foreign-located final goods firms, $\ell_t(z_{I|D}, x)$ ($\ell_t(z_{I|X}, x)$) is the labor of home household x employed by home intermediate goods firm $z_{I|D}$ ($z_{I|X}$), and $\xi > 1$ is the elasticity of substitution among labor varieties. First, the profit of a home intermediate goods firm $z_{I|D}$ is given as follows:

$$\Pi_{I,t}(z_{I|D}) = (\tilde{p}_{h,t}(z_{I|D}) - W_t)Y_{h,t}(z_{I|D}),$$

where $\tilde{p}_{h,t}(z_{I|D})$ is the home price, which corresponds to $Y_{h,t}(z_{I|D})$, and W_t is the aggregate wage index (shown below). Assuming that nominal wages are flexible, and given the demand function expressed in Eq.(A.10), the optimal price is determined as follows:[12]

$$\tilde{p}_{h,t}(z_{I|D}) = \frac{\sigma}{\sigma - 1} W_t \equiv \tilde{p}_{h,t}. \tag{12}$$

Eq.(12) shows that the home intermediate goods firm $z_{I|D}$ sets its product's price at the marginal cost (W_t) multiplied by the mark-up ratio ($\sigma/(\sigma - 1)$).

Next, the profits of a home PCP intermediate goods firm $z_{I|X}$ and a home LCP intermediate goods firm $z_{I|X}$ are given as follows:

$$\Pi^{PCP}_{I,t}(z_{I|X}) = (\tilde{p}^{PCP}_{h,t}(z_{I|X}) - W_t)Y^{*PCP}_{h,t}(z_{I|X}),$$

$$\Pi^{LCP}_{I,t}(z_{I|X}) = (\varepsilon_t \tilde{p}^{*LCP}_{h,t}(z_{I|X}) - W_t)Y^{*LCP}_{h,t}(z_{I|X}),$$

where $\tilde{p}^{PCP}_{h,t}(z_{I|X})$ ($\tilde{p}^{*LCP}_{h,t}(z_{I|X})$) is the home (foreign) price, which corresponds to $Y^{*PCP}_{h,t}(z_{I|X})$ ($Y^{*LCP}_{h,t}(z_{I|X})$).

As per the process of analysis adopted for profit maximization of the home intermediate goods firm $z_{I|D}$, the sales prices of these firms can be expressed in the following equation when nominal wages are flexible:

$$\tilde{p}^{PCP}_{h,t}(z_{I|X}) = \varepsilon_t \tilde{p}^{*LCP}_{h,t}(z_{I|X}) = \frac{\sigma}{\sigma - 1} W_t \equiv \tilde{p}_{h,t}. \tag{13}$$

Eq.(13) shows that the sales price of the PCP intermediate goods firm $z_{I|X}$ is equal to that of the LCP intermediate goods firm $z_{I|X}$. 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 mentioned in Section 3, our model takes into account nominal wage rigidity in the short run. Under sticky prices, which are established on the assumption of 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 changes in exchange rates to export prices denominated in the local currency. Focusing on a symmetric equilibrium, as shown in Corsetti and Pesenti (2005), the prices of the intermediate inputs sold in the export market, taking into account the incomplete pass through of the nominal exchange rate, are as follows:

$$\tilde{P}^*_{h,t} = \frac{\hat{\tilde{P}}_{h,t}}{\varepsilon_t^{1-\eta}}, \qquad \tilde{P}_{f,t} = \varepsilon_t^{1-\eta^*} \hat{\tilde{P}}^*_{f,t}, \tag{14}$$

[12]For Eq.(A.10), see Appendix A in the online appendices.

where $\hat{\tilde{P}}_{h,t}$ $\left(\hat{\tilde{P}}^*_{f,t}\right)$ is the predetermined component of $\tilde{P}^*_{h,t}$ $\left(\tilde{P}_{f,t}\right)$, which is the foreign (home)-currency price that corresponds to a composite of the inputs produced by home (foreign) export firms in the intermediate goods sector.

2.2 Households and government

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

$$U_t(x) = \sum_{s=t}^{\infty} \beta^{s-t} \left(lnC_s(x) + \chi ln \frac{M_s(x)}{P_s} - \kappa \ell_s(x) \right), \tag{15}$$

where $\beta \in (0,1)$ is the subjective discount factor, $C(x)$ is the aggregate consumption index of the home household x, $M(x)$ is the home household x's holdings of the home country's currency, P is the price, which corresponds to $C(x)$ (CPI), $\ell(x)$ 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[13]. The aggregate consumption index of home household x is given by:

$$C_t(x) = \frac{C^{\delta}_{T,t}(x) C^{1-\delta}_{N,t}(x)}{\delta^{\delta}(1-\delta)^{1-\delta}}, \tag{16}$$

where $C_{T,t}(x)$ and $C_{N,t}(x)$ are tradable and non-tradable composites, respectively, of differentiated final goods consumed by the home household x, and $\delta \in (0,1)$ is the share of tradables in the final goods consumed by the home household x. These variables are given by:

$$C_{T,t}(x) = \left((n_{D,t})^{\frac{1}{\rho}} (C_{h,t}(x))^{\frac{\rho-1}{\rho}} + (n^*_{X,t})^{\frac{1}{\rho}} (C_{f,t}(x))^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}, \tag{17}$$

$$C_{N,t}(x) = \left((n^*_{MN,t})^{\frac{1}{\theta}} C_{h|f'sMN,t}(x)^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}, \tag{18}$$

where

$$C_{h,t}(x) = \left((n_{D,t})^{-\frac{1}{\theta}} \int_0^{n_{D,t}} C_{h,t}(z_{F|D}, x)^{\frac{\theta-1}{\theta}} dz_{F|D} \right)^{\frac{\theta}{\theta-1}}, \tag{19}$$

$$C_{f,t}(x) = \left((n^*_{X,t})^{-\frac{1}{\theta}} \int_0^{n^*_{X,t}} C_{f,t}(z^*_{F|X}, x)^{\frac{\theta-1}{\theta}} dz^*_{F|X} \right)^{\frac{\theta}{\theta-1}}, \tag{20}$$

$$C_{h|f'sMN,t}(x) = \left((n^*_{MN,t})^{-\frac{1}{\theta}} \int_0^{n^*_{MN,t}} C_{h,t}(z_{F|MN}, x)^{\frac{\theta-1}{\theta}} dz_{F|MN} \right)^{\frac{\theta}{\theta-1}}. \tag{21}$$

[13]The utility function in this paper assumes a form that takes a linear disutility from working. By assuming this form, home and foreign wages are uniquely determined based on a first-order necessary condition on labor supply. This makes it possible to explain the effects of a positive home government spending shock on macroeconomic variables from an analytical investigation perspective.

In Eqs.(17) and (18), $C_{h,t}(x)$ ($C_{f,t}(x)$) and $C_{h|f'sMN,t}(x)$ are Dixit and Stiglitz (1977) type indexes of consumption by home household x across the tradables produced in the home (foreign) country and non-tradables produced in the home country, respectively. $\rho > 0$ is the elasticity of substitution between the final tradable goods produced in the home and foreign countries and $\theta > 1$ is the elasticity of substitution between any two differentiated final goods. In Eqs.(19)−(21), $C_{h,t}(z_{F|D}, x)$ is the consumption of the home final good $z_{F|D}$ by home household x, $C_{f,t}(z^*_{F|X}, x)$ is the consumption of the foreign final good $z^*_{F|X}$ by home household x, and $C_{h,t}(z_{F|MN}, x)$ is the consumption of the home final good $z_{F|MN}$ by home household x. We can define the CPI. In addition, we can also derive the demand function for each household in the home country. These are summarized in Appendix B in the online appendices.

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

$$\frac{B_{t+1}(x)}{P_t} + \frac{\varepsilon_t B^*_{t+1}(x)}{P_t} + \frac{M_t(x)}{P_t} + C_t(x) + \frac{I_t(x)}{P_t} + \frac{T_t(x)}{P_t}$$

$$= \frac{(1+i_t)B_t(x)}{P_t} + \frac{\varepsilon_t(1+i^*_t)B^*_t(x)}{P_t} + \frac{M_{t-1}(x)}{P_t} + \frac{w_t(x)\ell_t(x)}{P_t} + \frac{\Pi_{F,t}(x)}{P_t} + \frac{\Pi_{I,t}(x)}{P_t}, \qquad (22)$$

where $B_t(x)$ ($B^*_t(x)$) is the stock of home (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 (i^*_t) is the nominal interest rate between periods $t-1$ and t evaluated in home (foreign) currency terms, $w_t(x)$ is the nominal wage, which corresponds to $\ell_t(x)$, $T_t(x)$ is nominal taxes to the home government, and $\Pi_{F,t}(x)$ and $\Pi_{I,t}(x)$ are dividend revenues from the final and intermediate goods firms, respectively, that the home household x owns.

As mentioned in Corsetti et al. (2004, 2013), this paper assumes 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. Thus, the investment of the home household x in a diversified portfolio of final goods firms is defined as follows:

$$I_t(x) = \frac{1}{2}\Bigg(\sum_{j''=D,X} \int_0^{n_{j'',t}} q_t(z_{F|j''})dz_{F|j''} + \int_0^{n^*_{MN,t}} q_t(z_{F|MN})dz_{F|MN}$$

$$+\varepsilon_t \left(\sum_{j''=D,X} \int_0^{n^*_{j'',t}} q^*_t(z^*_{F|j''})dz^*_{F|j''} + \int_0^{n_{MN,t}} q^*_t(z^*_{F|MN})dz^*_{F|MN} \right) \Bigg).$$

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

$$\Pi_{F,t}(x) = \frac{1}{2}\Bigg(\sum_{j''=D,X} \int_0^{n_{j'',t}} \Pi_{F,t}(z_{F|j''})dz_{F|j''} + \int_0^{n^*_{MN,t}} \Pi_{F,t}(z_{F|MN})dz_{F|MN}$$

$$+\varepsilon_t\left(\sum_{j''=D,X}\int_0^{n^*_{j'',t}}\Pi^*_{F,t}(z^*_{F|j''})dz^*_{F|j''}+\int_0^{n_{MN,t}}\Pi^*_{F,t}(z^*_{F|MN})dz^*_{F|MN}\right)\Bigg).$$

In addition, the household is a monopolistic supplier of a differentiated labor service and faces the following labor-demand curve:

$$\ell_t(x)=\left(\frac{w_t(x)}{W_t}\right)^{-\xi}\left(\int_0^{\frac{1}{2}}Y_{h,t}(z_{I|D})dz_{I|D}+\int_{\frac{1}{2}}^{\frac{1+\eta}{2}}Y^{*LCP}_{h,t}(z_{I|X})dz_{I|X}+\int_{\frac{1+\eta}{2}}^{1}Y^{*PCP}_{h,t}(z_{I|X})dz_{I|X}\right), \tag{23}$$

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.

We now turn to the intertemporal maximization problem. Subject to Eq.(22), the home household x maximizes Eq.(15). Thus, the first-order necessary conditions for $C_t(x)$, $M_t(x)$ and $\ell_t(x)$ are derived as follows:

$$\frac{C_{t+1}(x)}{C_t(x)}=\beta(1+i_{t+1})\frac{P_t}{P_{t+1}}, \tag{24}$$

$$\frac{M_t(x)}{P_t}=\chi\frac{1+i_{t+1}}{i_{t+1}}C_t(x), \tag{25}$$

$$\frac{w_t(x)}{P_t}=\frac{\xi\kappa}{\xi-1}C_t(x). \tag{26}$$

Eq.(24) is the Euler equation, Eq.(25) is the real money demand function, and Eq.(26) 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 home households as a whole. For example, we define the aggregate 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, $B_{H,t}$ and $B_{F,t}$ in analogous ways for money holdings and two types of 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:

$$C_t=C_t(x),\quad M_t=M_t(x),\quad B_{H,t}=B_t(x),\quad B_{F,t}=B^*_t(x). \tag{27}$$

Taking into account Eqs.(24)$-$(27) 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:

$$\frac{C_{t+1}}{C_t}=\beta(1+i_{t+1})\frac{P_t}{P_{t+1}}, \tag{28}$$

$$\frac{M_t}{P_t}=\chi\frac{1+i_{t+1}}{i_{t+1}}C_t, \tag{29}$$

$$\frac{W_t}{P_t}=\frac{\xi\kappa}{\xi-1}C_t. \tag{30}$$

The budget constraint for the home government can be given as follows:

$$\frac{M_t - M_{t-1}}{P_t} + \frac{T_t}{P_t} = G_t.$$

Here, since the governments are assumed to purchase goods from home- and foreign-located final goods firms, G_t, the aggregate consumption index of the home government, is given by:

$$G_t = \frac{G_{T,t}^{\delta} G_{N,t}^{1-\delta}}{\delta^{\delta}(1-\delta)^{1-\delta}},$$

where $G_{T,t}$ and $G_{N,t}$ are tradable and non-tradable composites of differentiated final goods, respectively, that are consumed by the home government. These variables are given by:[14]

$$G_{T,t} = \left((n_{D,t})^{\frac{1}{\rho}} G_{h,t}^{\frac{\rho-1}{\rho}} + (n_{X,t}^*)^{\frac{1}{\rho}} G_{f,t}^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}},$$

$$G_{N,t} = \left((n_{MN,t}^*)^{\frac{1}{\theta}} G_{h|f'sMN,t}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}},$$

where

$$G_{h,t} = \left((n_{D,t})^{-\frac{1}{\theta}} \int_0^{n_{D,t}} G_{h,t}(z_{F|D})^{\frac{\theta-1}{\theta}} dz_{F|D} \right)^{\frac{\theta}{\theta-1}},$$

$$G_{f,t} = \left((n_{X,t}^*)^{-\frac{1}{\theta}} \int_0^{n_{X,t}^*} G_{f,t}(z_{F|X}^*)^{\frac{\theta-1}{\theta}} dz_{F|X}^* \right)^{\frac{\theta}{\theta-1}},$$

$$G_{h|f'sMN,t} = \left((n_{MN,t}^*)^{-\frac{1}{\theta}} \int_0^{n_{MN,t}^*} G_{h,t}(z_{F|MN})^{\frac{\theta-1}{\theta}} dz_{F|MN} \right)^{\frac{\theta}{\theta-1}}.$$

We make the following assumption about consumption substitutability. To begin with, we assume that the elasticity of substitution among the final goods produced in one country is likely to be higher than the elasticity of substitution across the final tradable goods produced in different countries, namely $\rho \leq \theta$. We also assume that final tradable goods produced in different countries are close substitutes, namely, $\rho > 1$. Therefore, we get the following magnitude relationship for consumption substitutability: $1 < \rho \leq \theta$.

Here, although our analytical purpose is to examine the effects of an unanticipated permanent government spending shock of the home country, in our model, it is analytically convenient to introduce a measure of monetary stance $\mu_t \equiv P_t C_t$.[15] Using this measure, we

[14] See Appendix C in the online appendices for public demand for goods produced by the three types of final goods firms selling in the home country.

[15] Our definition of the variables of monetary policy is based on those in Corsetti and Pesenti (2005) and Corsetti and Dedola (2005). In this definition, the government controls nominal consumption. Further, as mentioned in footnotes 20 and 21, we use the relationship $B_{H,t+1} = B_{H,t+1}^* = B_{F,t+1} = B_{F,t+1}^* = B_{H,t} = B_{H,t}^* = B_{F,t} = B_{F,t}^* = 0$. Therefore, a temporary home monetary easing at period t, associated with a higher μ_t, leads to a lower i_{t+1}.

can rewrite Eqs.(28) and (29) as follows:

$$\frac{1}{\mu_t} = \beta(1+i_{t+1})\frac{1}{\mu_{t+1}}, \qquad M_t = \chi\frac{1+i_{t+1}}{i_{t+1}}\mu_t.$$

Now, we define the equilibrium conditions for the asset market. The worldwide net supply of bonds has to be equal to zero. Therefore, the equilibrium conditions for the asset market are given as follows:

$$B_{H,t} + B^*_{H,t} = 0, \qquad B_{F,t} + B^*_{F,t} = 0.$$

2.3 Final goods prices, price indexes of final goods and CPIs

This subsection derives the prices of final goods and uses them to rewrite price indexes of final goods and CPIs. Using Eqs.(4), (6), (B.23) and (C.1), we can easily derive the optimal price for the goods sold by domestic market firm $z_{F|D}$, which belongs to the home-located tradable sector final goods firms as follows:[16]

$$p_{h,t}(z_{F|D}) = \frac{\theta}{\theta-1}\Lambda_t \equiv p_{h,t}. \tag{31}$$

Similarly, we can also derive the optimal prices for the goods sold by export firm $z^*_{F|X}$, which belongs to the foreign-located tradable sector final goods firms, and foreign multinational firm $z_{F|MN}$, which belongs to the home-located non-tradable sector final goods firms as follows:

$$\frac{p_{f,t}(z^*_{F|X})}{\varepsilon_t} = \frac{\theta}{\theta-1}\Lambda^*_t \equiv p^*_{f,t}, \tag{32}$$

$$p_{h,t}(z_{F|MN}) = \frac{\theta}{\theta-1}\Lambda_t \equiv p_{h,t}. \tag{33}$$

With regard to the final goods firms selling in the foreign market, we can derive the optimal prices for the goods of these firms as follows:

$$p^*_{f,t}(z^*_{F|D}) = p^*_{f,t}(z^*_{F|MN}) = \frac{\theta}{\theta-1}\Lambda^*_t \equiv p^*_{f,t}, \tag{34}$$

$$\varepsilon_t p^*_{h,t}(z_{F|X}) = \frac{\theta}{\theta-1}\Lambda_t \equiv p_{h,t}. \tag{35}$$

Here, using Eqs.(12)−(14) and (A.5), the unit costs of producing home and foreign final goods, which are given in Eqs.(A.1) and (A.2), can be represented as $\Lambda_t = 2^{\frac{1}{\sigma-1}}\frac{\sigma}{\sigma-1}\varepsilon_t^{\frac{1-\eta^*}{2}}W_t$ and $\Lambda^*_t = 2^{\frac{1}{\sigma-1}}\frac{\sigma}{\sigma-1}\varepsilon_t^{\frac{\eta-1}{2}}W^*_t$.[17] Therefore, from these two expressions and Eqs.(31)−(35), $p_{h,t}$ and $p^*_{f,t}$ can be rewritten as follows:

$$p_{h,t} = 2^{\frac{1}{\sigma-1}}\frac{\theta}{\theta-1}\frac{\sigma}{\sigma-1}\varepsilon_t^{\frac{1-\eta^*}{2}}W_t,$$

[16]For Eqs.(B.23) and (C.1), see Appendix B and Appendix C in the online appedices, respectively.
[17]For Eqs.(A.1), (A.2), and (A.5), see Appendix A in the online appendices.

$$p^*_{f,t} = 2^{\frac{1}{\sigma-1}} \frac{\theta}{\theta-1} \frac{\sigma}{\sigma-1} \varepsilon_t^{\frac{\eta-1}{2}} W^*_t.$$

Also from Eqs.(B.3)−(B.6), $P_{T,t}$ and $P_{N,t}$, which correspond to the price indexes for tradable and non-tradable composites of differentiated final goods consumed by home households and $P^*_{T,t}$ and $P^*_{N,t}$, which correspond to the price indexes for tradable and non-tradable composites of differentiated final goods consumed by foreign households are given as:[18]

$$P_{T,t} = p_{h,t}\Phi_t^{\frac{1}{1-\rho}}, \qquad P_{N,t} = p_{h,t}{n^*}_{MN,t}^{\frac{1}{1-\theta}}, \tag{36}$$

$$P^*_{T,t} = p^*_{f,t}{\Phi^*_t}^{\frac{1}{1-\rho}}, \qquad P^*_{N,t} = p^*_{f,t}n_{MN,t}^{\frac{1}{1-\theta}}, \tag{37}$$

where $\Phi_t \equiv n_{D,t} + n^*_{X,t}TOT_t^{1-\rho}$ and $\Phi^*_t \equiv n^*_{D,t} + n_{X,t}TOT_t^{\rho-1}$.[19]

From Eqs.(36) and (37), the CPIs of both countries are given as:

$$P_t = p_{h,t}{n^*}_{MN,t}^{\frac{1-\delta}{1-\theta}}\Phi_t^{\frac{\delta}{1-\rho}},$$

$$P^*_t = p^*_{f,t}n_{MN,t}^{\frac{1-\delta}{1-\theta}}{\Phi^*_t}^{\frac{\delta}{1-\rho}}.$$

2.4 Free entry and the balance of trade

This subsection mainly presents the conditions that hold under a situation of free entry and the balance of payments of the home country. To begin with, using Eqs.(4)−(7), (31), (33) and (35), the profits earned by the home-located final goods firms can be given as follows:

$$\Pi_{F,t}(z_{F|D}) = \frac{p_{h,t}Y_t(z_{F|D})}{\theta} = \frac{\delta}{\theta}\left(\frac{\mu_t}{\Phi_t} + \frac{p_{h,t}G_t}{{n^*}_{MN,t}^{\frac{1-\delta}{\theta-1}}\Phi_t^{\frac{\rho-(1-\delta)}{\rho-1}}}\right), \tag{38}$$

$$\Pi_{F,t}(z_{F|X}) = \frac{p_{h,t}Y_t(z_{F|X})}{\theta} = \frac{\delta}{\theta}\left(\frac{\varepsilon_t\mu^*_t TOT_t^{\rho-1}}{\Phi^*_t} + \frac{TOT_t^{\rho}p_{h,t}G^*_t}{n_{MN,t}^{\frac{1-\delta}{\theta-1}}{\Phi^*_t}^{\frac{\rho-(1-\delta)}{\rho-1}}}\right), \tag{39}$$

$$\Pi_{F,t}(z_{F|MN}) = \frac{p_{h,t}Y_t(z_{F|MN})}{\theta} = \frac{1-\delta}{\theta}\left(\frac{\mu_t}{n^*_{MN,t}} + \frac{p_{h,t}G_t}{{n^*}_{MN,t}^{\frac{\theta-\delta}{\theta-1}}\Phi_t^{\frac{\delta}{\rho-1}}}\right). \tag{40}$$

Similarly, the profits earned by the foreign-located final goods firms can be given as follows:

$$\Pi^*_{F,t}(z^*_{F|D}) = \frac{p^*_{f,t}Y^*_t(z^*_{F|D})}{\theta} = \frac{\delta}{\theta}\left(\frac{\mu^*_t}{\Phi^*_t} + \frac{p^*_{f,t}G^*_t}{n_{MN,t}^{\frac{1-\delta}{\theta-1}}{\Phi^*_t}^{\frac{\rho-(1-\delta)}{\rho-1}}}\right), \tag{41}$$

[18] For Eqs.(B.3)−(B.6), see Appendix B in the online appendices.

[19] The terms of trade under trade in final goods are defined as $TOT_t \equiv \frac{\varepsilon_t p^*_{f,t}}{p_{h,t}}$.

$$\Pi^*_{F,t}(z^*_{F|X}) = \frac{p^*_{f,t}Y^*_t(z^*_{F|X})}{\theta} = \frac{\delta}{\theta}\left(\frac{\left(\frac{\mu_t}{\varepsilon_t}\right)TOT_t^{1-\rho}}{\Phi_t} + \frac{TOT_t^{-\rho}p^*_{f,t}G_t}{{n^*_{MN,t}}^{\frac{1-\delta}{\theta-1}}{\Phi^*_t}^{\frac{\rho-(1-\delta)}{\rho-1}}}\right), \tag{42}$$

$$\Pi^*_{F,t}(z^*_{F|MN}) = \frac{p^*_{f,t}Y^*_t(z^*_{F|MN})}{\theta} = \frac{1-\delta}{\theta}\left(\frac{\mu^*_t}{n_{MN,t}} + \frac{p^*_{f,t}G^*_t}{n_{MN,t}^{\frac{\theta-\delta}{\theta-1}}{\Phi^*_t}^{\frac{\delta}{\rho-1}}}\right). \tag{43}$$

Other things being equal, Eqs.(38)−(43) show that a higher number of final goods firms in a sector reduces the profits of each final goods firm in that sector.

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

$$q_t(z_{F|D}) = (\tilde{P}_{h,t} + \tilde{P}_{f,t})n^{\gamma}_{D,t} = \Pi_{F,t}(z_{F|D}), \tag{44}$$

$$q_t(z_{F|X}) = (\tilde{P}_{h,t} + \tilde{P}_{f,t})n^{\gamma}_{X,t} = \Pi_{F,t}(z_{F|X}), \tag{45}$$

$$q_t(z_{F|MN}) = (\tilde{P}_{h,t} + \tilde{P}_{f,t})n^{*\gamma}_{MN,t} = \Pi_{F,t}(z_{F|MN}). \tag{46}$$

We define these relationships as the free entry conditions of the home country. Similarly, the free entry conditions of the foreign country can be given as follows:

$$q^*_t(z^*_{F|D}) = (\tilde{P}^*_{h,t} + \tilde{P}^*_{f,t})n^{*\gamma}_{D,t} = \Pi^*_{F,t}(z^*_{F|D}), \tag{47}$$

$$q^*_t(z^*_{F|X}) = (\tilde{P}^*_{h,t} + \tilde{P}^*_{f,t})n^{*\gamma}_{X,t} = \Pi^*_{F,t}(z^*_{F|X}), \tag{48}$$

$$q^*_t(z^*_{F|MN}) = (\tilde{P}^*_{h,t} + \tilde{P}^*_{f,t})n^{\gamma}_{MN,t} = \Pi^*_{F,t}(z^*_{F|MN}). \tag{49}$$

Next, aggregating the budget constraints of households in the home country and using the government budget constraint and the relationship $B_{H,t+1} = B_{H,t} = B_{F,t+1} = B_{F,t} = 0$, the balance of trade of the home country can be given as follows:[20]

$$\delta\frac{n_{X,t}(\varepsilon_t\mu^*_t)TOT_t^{\rho-1}}{\Phi^*_t} + \delta\frac{n_{X,t}G^*_t p_{h,t}TOT_t^{\rho}}{{n^*_{MN,t}}^{\frac{1-\delta}{\theta-1}}{\Phi^*_t}^{\frac{\rho-(1-\delta)}{\rho-1}}} - \frac{n^*_{X,t}TOT_t^{1-\rho}}{\Phi_t}\left(\delta\mu_t + \frac{\delta p_{h,t}G_t}{{n^*_{MN,t}}^{\frac{1-\delta}{\theta-1}}\Phi_t^{\frac{\delta}{\rho-1}}}\right) = 0. \tag{50}$$

On the left-hand side of Eq.(50), the first and second terms represent home exports, while the third and fourth terms represent home imports.

[20]With regard to the relationship $B_{H,t+1} = B_{H,t} = B_{F,t+1} = B_{F,t} = 0$, refer to footnote 21.

3 Transmission mechanism in an economy without trade in international bonds

This section examines the effects of an unanticipated permanent government spending shock in the home country.[21] 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, a home government spending shock occurs, and a short-run equilibrium is seen, which assumes that nominal wages are fixed, before the shock can be observed. In the long run (from period $t+1$ onward), nominal wages are determined based on Eq.(30) and its foreign analog, and all variables reach their new steady-state values. Variables in the initial steady-state are hereafter represented without a time subscript. Variables in the short-run and long-run equilibriums are represented in terms of deviations from the initial steady-state with $G = G^* = 0$, $B_H = B_H^* = B_F = B_F^* = 0$ and $\mu = \mu^* = 1$ $\left(\widehat{X} \equiv \frac{dX_t}{X},\ \widehat{\overline{X}} \equiv \frac{dX_{t+1}}{X}\right)$.[22] In this steady state, our model has the solutions such as $n_D = n_X = n_D^* = n_X^*$, $n_{MN}^* = n_{MN}$, $\ell = \ell^* = (2^{\frac{2\sigma-1}{\sigma-1}}\theta/\delta)n_D^{1+\gamma} = (2^{\frac{\sigma}{\sigma-1}}\theta/(1-\delta))n_{MN}^{*1+\gamma}$ and $\varepsilon = 1$ (see Appendix D in the online appendices).

This section examines both the short-run and long-run effects of the shock. The short-run effects are examined, in particular, by focusing on the degree of LCP, while the long-run effects are examined by focusing on the persistence of the shock.[23]

3.1 The relationships between various macroeconomic variables in the short-run and long-run equilibriums

The next subsection will examine the effects of a home government spending shock on the macroeconomic variables. The effects will be examined especially by focusing on the degree of LCP and the difference between the short-run and long-run equilibriums.

Before the above analysis, however, this subsection first linearizes each of Eqs.(44)−(50) and considers the relationships between various macroeconomic variables. From Eqs.(44) and (45), we obtain the following equations:

- The short-run equilibrium

$$\frac{1}{2}\widehat{n_D} = -\frac{1}{2}\widehat{n_X^*} + \frac{(\rho-1)(\eta+\eta^*)}{4}\widehat{\varepsilon} + \widehat{\overline{G}} - \widehat{q(z_{F|D})}, \tag{51}$$

[21] This paper focuses on analytical investigation as much as possible. Therefore, the effects of a positive home government spending shock are examined by ruling out trade in international bonds. This assumption is based on Corsetti et al. (2004) and Cavallari (2010).

[22] With regard to home government spending, its short-run and long-run deviations are denoted by $\widehat{G}\left(=\frac{dG_t}{C}\right)$ and $\widehat{\overline{G}}\left(=\frac{dG_{t+1}}{C}\right)$, respectively, since its initial value is zero.

[23] This paper assumes that the nominal money balances are always constant at the initial steady state level and that, therefore, unanticipated permanent government expenditures in the home country are financed by permanent tax increases.

$$\frac{1}{2}\widehat{n_X} = -\frac{1}{2}\widehat{n_D^*} + \frac{(\rho-1)(\eta+\eta^*)+4}{4}\widehat{\varepsilon} - \widehat{q(z_{F|X})}, \tag{52}$$

- The long-run equilibrium

$$\frac{1}{2}\widehat{n_D} = -\frac{1}{2}\widehat{n_X^*} + \widehat{\overline{G}} - \widehat{q(z_{F|D})}, \tag{53}$$

$$\frac{1}{2}\widehat{n_X} = -\frac{1}{2}\widehat{n_D^*} + \widehat{\overline{\varepsilon}} - \widehat{q(z_{F|X})}. \tag{54}$$

Eqs.(51) and (52) have the following characteristics. To begin with, when the number of export (domestic market) firms among foreign-located final goods firms, i.e., $\widehat{n_X^*}$ $\left(\widehat{n_D^*}\right)$, increases, the home (foreign) household's consumption of final goods produced in the home country decreases, which causes a decrease in the sales revenues of domestic market (export) firms among home-located final goods firms, thereby decreasing profits for these domestic market (export) firms. Consequently, it leads to their exit from the home market. These relationships are also shown in the long-run equilibrium (see Eqs.(53) and (54)). Next, when the nominal exchange rate depreciates ($\widehat{\varepsilon} > 0$), it increases the sales revenues of domestic market and export firms among home-located final goods firms. The increase in the sales revenues of domestic market firms among home-located final goods firms is solely due to a deterioration of the home country's terms of trade caused by the nominal exchange rate depreciation. The increase in the sales revenues of export firms among home-located final goods firms is due to the deterioration of the home country's terms of trade caused by the nominal exchange rate depreciation as well as an increase in sales revenues in terms of the home country's currency due to the nominal exchange rate depreciation. This increase in the sales revenues of domestic market and export firms among home-located final goods firms causes an increase in the profits of these two types of firms. Consequently, there is an increase in the number of these two types of firms. Additionally, from the perspective of LCP in both countries, we can show that these results have the following properties. When the value of η and/or η^* rises, the increase in the number of domestic market and export firms among home-located final goods firms gets steeper. This is because a rise in η and/or η^* causes a steeper increase in profits for these two types of firms through a sharper deterioration in the home country's terms of trade under trade in final goods.[24] Note that these parameters disappear in the long-run equilibrium (see Eqs.(53) and (54)). This is because the sales price of the LCP intermediate goods firm is equal to that of the PCP intermediate goods firm. Further, from the perspective of the elasticity of substitution between final tradable goods produced in the home and foreign countries, we can also show that these results have the following properties. When the value of ρ rises, the increase in the number of these two types of firms gets steeper. This is because the rise in this value causes an increasing shift in demand from the final tradable goods produced in the foreign country to the final tradable goods produced

[24]The terms of trade under trade in final goods is defined as $TOT_t = \frac{\varepsilon_t p^*_{f,t}}{p_{h,t}}$. Thus, a first-order approximation for TOT_t can be given as $\widehat{TOT} = \frac{\eta+\eta^*}{2}\widehat{\varepsilon}$.

in the home country. Finally, when G_t increases $\left(\widehat{\overline{G}} > 0\right)$, the home government's spending toward final goods sold in the home country increases, which causes an increase in the sales revenues of domestic market firms among home-located final goods firms. Consequently, it leads to firm entry into the home market. This relationship is also shown in the long-rum equilibrium (see Eq.(53)).

From Eqs.(47) and (48), we obtain the following equations:

- The short-run equilibrium

$$\frac{1}{2}\widehat{n_D^*} = -\frac{1}{2}\widehat{n_X} - \frac{(\rho-1)(\eta+\eta^*)}{4}\widehat{\varepsilon} - \widehat{q^*(z_{F|D}^*)}, \tag{55}$$

$$\frac{1}{2}\widehat{n_X^*} = -\frac{1}{2}\widehat{n_D} - \frac{(\rho-1)(\eta+\eta^*)+4}{4}\widehat{\varepsilon} + \widehat{\overline{G}} - \widehat{q^*(z_{F|X}^*)}, \tag{56}$$

- The long-run equilibrium

$$\frac{1}{2}\widehat{\overline{n_D^*}} = -\frac{1}{2}\widehat{\overline{n_X}} - \widehat{\overline{q^*(z_{F|D}^*)}}, \tag{57}$$

$$\frac{1}{2}\widehat{\overline{n_X^*}} = -\frac{1}{2}\widehat{\overline{n_D}} - \widehat{\overline{\varepsilon}} + \widehat{\overline{G}} - \widehat{\overline{q^*(z_{F|X}^*)}}. \tag{58}$$

Eqs.(55) and (56) have the following characteristics. To begin with, when the number of export (domestic market) firms among home-located final goods firms, i.e., $\widehat{n_X}$ ($\widehat{n_D}$), increases, the foreign (home) household's consumption of final goods produced in the foreign country decreases, which causes a decrease in the sales revenues of domestic market (export) firms among foreign-located final goods firms, thereby decreasing profits for these domestic market (export) firms. Consequently, it leads to their exit from the foreign market. These relationships are also shown in the long-run equilibrium (see Eqs.(57) and (58)). Next, when the nominal exchange rate depreciates ($\widehat{\varepsilon} > 0$), it decreases the sales revenues of domestic market and export firms among foreign-located final goods firms. The decrease in sales revenues of domestic market firms among foreign-located final goods firms is solely due to an improvement of the foreign country's terms of trade caused by the nominal exchange rate depreciation. The decrease in sales revenues of export firms among foreign-located final goods firms is due to an improvement in the foreign country's terms of trade caused by the nominal exchange rate depreciation as well as a decrease in sales revenues in terms of the foreign country's currency due to the nominal exchange rate depreciation. This decrease in sales revenues of domestic market and export firms among foreign-located final goods firms causes a decline in the profits of these two types of firms. Consequently, there is a decline in the number of these two types of firms. In addition, from the perspective of LCP in both countries, we can show that these results have the following properties. When the value of η and/or η^* rises, the decrease in the number of domestic market and export firms among foreign-located final goods firms gets steeper. This is because a rise in η and/or η^* causes a sharper reduction in profits for these two types of firms through a steeper improvement in the foreign country's terms of trade under

trade in final goods. Note that these parameters also disappear in the long-run equilibrium (see Eqs.(57) and (58)). Further, from the perspective of the elasticity of substitution between the final tradable goods produced in the home and foreign countries, we can also show that the rise in the value of ρ intensifies the decrease in the number of these two types of firms. Finally, when G_t increases $\left(\widehat{\overline{G}} > 0\right)$, the home government's spending toward final goods sold in the home country increases, which causes an increase in the sales revenues of export firms among foreign-located final goods firms. Consequently, it leads to firm entry into the foreign market. This relationship is also shown in the long-run equilibrium (see Eq.(58)).

From Eqs.(46) and (49), we obtain the following equations:

- The short-run equilibrium

$$\widehat{n^*_{MN}} = \widehat{\overline{G}} - q(\widehat{z_{F|MN}}), \tag{59}$$

$$\widehat{n_{MN}} = -q^*(\widehat{z^*_{F|MN}}), \tag{60}$$

- The long-run equilibrium

$$\widehat{\overline{n^*_{MN}}} = \widehat{\overline{G}} - \widehat{\overline{q(z_{F|MN})}}, \tag{61}$$

$$\widehat{\overline{n_{MN}}} = -\widehat{\overline{q^*(z^*_{F|MN})}}.$$

Eq.(59) has the following characteristics. An increase in G_t $\left(\widehat{\overline{G}} > 0\right)$ increases profits for foreign multinational firms among home-located final goods firms, since it causes an increase in the sales revenues of this firm. Consequently, it encourages new entry into the home market. This relationship is also shown in the long-run equilibrium (see Eq.(61)).

From Eq.(50), we obtain the following equations:

- The short-run equilibrium

$$\frac{(\rho-1)(\eta+\eta^*)+2}{2}\widehat{\varepsilon} = -\frac{1}{2}\left(\widehat{n_D} - \widehat{n^*_X}\right) + \frac{1}{2}\left(\widehat{n^*_D} - \widehat{n_X}\right) + \widehat{\overline{G}}, \tag{62}$$

- The long-run equilibrium

$$\widehat{\overline{\varepsilon}} = -\frac{1}{2}\left(\widehat{\overline{n_D}} - \widehat{\overline{n^*_X}}\right) + \frac{1}{2}\left(\widehat{\overline{n^*_D}} - \widehat{\overline{n_X}}\right) + \widehat{\overline{G}}. \tag{63}$$

Eq.(62) has the following characteristics. To begin with, an increase in the relative number of final tradable goods firms selling in the home country $\left(\widehat{n_D} - \widehat{n^*_X}\right)$ leads to an appreciation of the nominal exchange rate. The balance of trade is restored via the appreciation, since such an increase leads to an increase in the net export of final tradable goods. Next, an increase

in the relative number of final tradable goods firms selling in the foreign country $\left(\widehat{n_D^*} - \widehat{n_X}\right)$ leads to a depreciation of the nominal exchange rate. Unlike in the previous case, the balance of trade is restored via the depreciation, since such an increase leads to a decrease in the net export of final tradable goods. Finally, an increase in G_t $\left(\widehat{\overline{G}} > 0\right)$ leads to a decrease in the net export of final tradable goods. Consequently, it leads to a depreciation of the nominal exchange rate. These relationships are also shown in the long-run equilibrium (see Eq.(63)).

3.2 Effects of a government spending shock on macroeconomic variables

This subsection analyzes the effects of a government spending shock.

3.2.1 Effects on the nominal exchange rate

This subsubsection examines the effect of a positive home government spending shock on nominal exchange rates. The short-run nominal exchange rate is obtained using the following steps.

To begin with, from Eqs.(51) and (56), we derive:

$$\frac{\widehat{n_D}}{\widehat{\overline{G}}} - \frac{\widehat{n_X^*}}{\widehat{\overline{G}}} = \frac{\rho(\eta + \eta^*)}{2\gamma} \frac{\widehat{\varepsilon}}{\widehat{\overline{G}}}. \tag{64}$$

Next, from Eqs.(52) and (55), we derive:

$$\frac{\widehat{n_D^*}}{\widehat{\overline{G}}} - \frac{\widehat{n_X}}{\widehat{\overline{G}}} = -\frac{\rho(\eta + \eta^*)}{2\gamma} \frac{\widehat{\varepsilon}}{\widehat{\overline{G}}}. \tag{65}$$

Therefore, from Eqs.(62), (64) and (65), we derive:

$$\frac{\widehat{\varepsilon}}{\widehat{\overline{G}}} = \frac{2\gamma}{\Delta} > 0, \tag{66}$$

where $\Delta \equiv \rho(\eta + \eta^*) + \gamma\{2 + (\rho - 1)(\eta + \eta^*)\} > 0$. The long-run nominal exchange rate is also obtained in a manner similar to that used to derive the short-run nominal exchange rate as follows.

$$\frac{\widehat{\overline{\varepsilon}}}{\widehat{\overline{G}}} = 1 > 0. \tag{67}$$

Eqs.(66) and (67) show that this shock unambiguously leads to a depreciation of the nominal exchange rate in both the short-run and long-run equilibriums. Since the mechanism of this result is the same in both short-run and long-run equilibriums, we can use the equations for the short-run equilibrium to explain it as follows. Eqs.(51) and (56) show that, when this shock occurs, the number of domestic market firms among home-located final goods firms and export firms among foreign-located final goods firms increases equally. Although the prices of

export firms among foreign-located final goods firms are the same as the prices of domestic market firms among home-located final goods firms, the prices of the former firms are lower than they were before the shock, and thus the value of home imports increases. This causes a trade deficit in the home country, which in turn causes the nominal exchange rate to depreciate to balance out the trade deficit. In addition, Eq.(66) also shows that the degree of depreciation decreases in response to the rise in η and/or η^*. This can be explained as follows. To begin with, from Eqs.(64) and (65), when the value of η and/or η^* rises, the relative number of final tradable goods firms selling in the home country increases, and the relative number of final tradable goods firms selling in the foreign country decreases. These arise from a deterioration in the terms of trade of the home country, and hence reduce the magnitude of the trade deficits in the home country. In addition, the magnitude of the trade deficit also decreases with an increase in the value of η and/or η^*, which is the component of coefficient of $d\varepsilon_t$ in Eq.(62). Consequently, from these two perspectives, the degree of depreciation, which is required to correct the resulting trade deficit, decreases. Here, Eq.(67) shows that, except in a full PCP situation, the degree of long-run depreciation exceeds the degree of short-run depreciation and is equal to the magnitude of this shock. This can be explained as follows. Even though there are LCP firms in the intermediate goods sector, the situation in the long-run equilibrium will be the same as if there were only PCP firms in the intermediate goods sector. Therefore, from Eqs.(64) and (65), the values of $\widehat{\overline{n_D}}$ and $\widehat{\overline{n_X^*}}$ are equal, and the values of $\widehat{\overline{n_D^*}}$ and $\widehat{\overline{n_X}}$ are equal. Consequently, from Eq.(63), the degree of the long-run depreciation is equal to the magnitude of this shock.

3.2.2 Effects on the number of final goods firms

This subsubsection examines the effects of a positive home government spending shock on the number of different types of final goods firms.[25] To begin with, from Eqs.(51), (52), (55), (56) and (66), the number of domestic market and export firms among home-located final goods firms in the short-run equilibrium are as follows:

$$\frac{\widehat{n_D}}{\widehat{G}} = \frac{1}{1+\gamma} + \frac{\rho(1+\gamma)(\eta+\eta^*) - \gamma(2+\eta-\eta^*)}{2(1+\gamma)\Delta} > 0, \tag{68}$$

$$\frac{\widehat{n_X}}{\widehat{G}} = \frac{\rho(1+\gamma)(\eta+\eta^*) + \gamma(2+\eta^*-\eta)}{2(1+\gamma)\Delta} > 0. \tag{69}$$

Eqs.(68) and (69) show that the effects of this shock on the number of domestic market and export firms among home-located final goods firms in the short-run equilibrium are positive.[26]

[25] The fluctuation in the number of various final goods firms ought ideally to be explained by movements in all the variables represented by each of the required free entry conditions. However, the explanations here are in terms of the direct effect of a change in the policy variable, the effect of changes in the nominal exchange rate, and the effect of changes in entry costs due to the depreciation of the nominal exchange rate, based on the implications derived from the initial response to a positive home government spending shock.

[26] Our model does not include the features of the so-called Melitz (2003) model. However, if included, a positive home government spending shock would affect both the thresholds of both production and exporting decisions, so the total effect on the number of exporters is ambiguous.

This result can be explained intuitively as follows. When the shock occurs, the profits for these two types of firms increase. Specifically, the profits for domestic market firms among home-located final goods firms increase as a direct effect of the shock and nominal exchange rate depreciation. The profits for export firms among home-located final goods firms increase through nominal exchange rate depreciation. At the same time, it increases entry costs for these two types of firms through a depreciation of the nominal exchange rate. However, the profits are greater than the entry costs for both types of firms. Consequently, there is an increase in the number of these two types of firms as the shock increases the difference between profits and entry costs for both (see Eqs.(51), (52) and (66)). Here, differentiating Eq.(68) with respect to η and η^*, we can show that the rise in η and/or η^* intensifies the increase in the number of domestic market firms among home-located final goods firms. This can be explained as follows. The larger the value of η and/or η^*, the greater the increase in difference between profits and entry costs for domestic market firms among home-located final goods firms. This means that the steeper increase in profits due to the sharper deterioration in the home country's terms of trade and the weaker increase in entry costs due to a weaker nominal exchange rate depreciation contribute significantly to a steeper increase in this difference. Consequently, the degree of the increase in the number of these domestic market firms intensifies. On the other hand, differentiating Eq.(69) with respect to η and η^*, we can show that a rise in η essentially weakens the increase in the number of export firms among home-located final goods firms, while a rise in η^* intensifies the increase in the number of these export firms. In particular, the latter result can be explained based on the intensification of the increase in difference between profits and entry costs for these export firms. This is based on an acceleration of the weakening of the increase in entry costs caused by both the weakening of the nominal exchange rate depreciation and the weakening of the nominal exchange rate pass-through, although the increase in profits due to this depreciation will also weaken.[27] In another analysis, comparing scenarios with and without vertical trade, we may be able to show that the number of domestic market firms and exporters among home-located final goods firms increases significantly in the latter. This is because, in the scenario with vertical trade, nominal exchange rate depreciation increases entry costs for these two types of final goods firms, whereas, in the scenario without vertical trade, entry costs for these firms remain constant despite nominal exchange rate depreciation due to these firms not requiring imported foreign intermediate goods for market entry.

Next, from Eqs.(51), (52), (55), (56) and (66), the number of domestic market and export firms among foreign-located final goods firms in the short-run equilibrium are as follows:

$$\frac{\widehat{n_D^*}}{\widehat{\overline{G}}} = \frac{\gamma(2+\eta^*-\eta)-\rho(1+\gamma)(\eta+\eta^*)}{2(1+\gamma)\Delta}, \tag{70}$$

$$\frac{\widehat{n_X^*}}{\widehat{\overline{G}}} = \frac{1}{1+\gamma} - \frac{\rho(1+\gamma)(\eta+\eta^*)+\gamma(2+\eta-\eta^*)}{2(1+\gamma)\Delta} > 0. \tag{71}$$

[27]The effect of this shock on $q_t(z_{F|X})$ can be given as $\frac{\widehat{q(z_{F|X})}}{\widehat{\overline{G}}} = \frac{1-\eta^*}{2}\frac{\widehat{\varepsilon}}{\widehat{\overline{G}}} + \gamma\frac{\widehat{n_X}}{\widehat{\overline{G}}}$.

Eq.(70) shows that the effect of this shock on the number of domestic market firms among foreign-located final goods firms is ambiguous, while Eq.(71) shows that the effect of this shock on the number of export firms among foreign-located final goods firms is positive. These results can be explained intuitively as follows. To begin with, when this shock occurs, the profits for domestic market firms among foreign-located final goods firms decrease. Specifically, under conditions other than full PCP, the profits for these firms decrease as a result of the depreciation of the nominal exchange rate. At the same time, it also causes a decrease in entry costs for these firms through the depreciation of the nominal exchange rate. The magnitude relation of these two decreases is determined by the size of two types of LCP parameters. Consequently, the effect on the number of these firms is ambiguous. On the other hand, while this shock lowers the entry costs for export firms among foreign-located final goods firms through nominal exchange rate depreciation, it also essentially increases the profits for these firms. A significant portion of the increase in the profits for these firms is as a direct result of this shock. Consequently, there is an increase in the number of these firms (see Eqs.(55), (56) and (66)). Here, differentiating Eq.(70) with respect to η and η^*, we can show that a rise in η and/or η^* weakens (or intensifies) the increase in (or the decrease in) the number of domestic market firms among foreign-located final goods firms. On the other hand, differentiating Eq.(71) with respect to η and η^*, we can show that a rise in η weakens the increase in the number of export firms among foreign-located final goods firms, while a rise in η^* essentially intensifies the increase in the number of these export firms. These mechanisms can also be explained using the same logic as adopted for the result obtained from Eq.(69). For example, the latter result can be explained based on an intensification in the increase in difference between profits and entry costs for these export firms. This is based on a deceleration of the weakening of the decrease in entry costs caused solely by the weakening of the nominal exchange rate depreciation, although the increase in profits due to this depreciation will also intensify.[28] In another analysis, comparing the scenarios with and without vertical trade, we may be able to show that the number of domestic market firms and exporters among foreign-located final goods firms is significantly reduced in the latter. This is because, in the scenario with vertical trade, nominal exchange rate depreciation decreases entry costs for these two types of final goods firms, whereas, in the scenario without vertical trade, entry costs for these firms remain constant despite nominal exchange rate depreciation due to these firms not requiring imported home intermediate goods for market entry.

Further, from Eqs.(59), (60) and (66), the number of foreign multinational firms among home-located final goods firms in the short-run equilibrium, and that of home multinational firms among foreign-located final goods firms in the short-run equilibrium are as follows:

$$\frac{\widehat{n^*_{MN}}}{\widehat{\overline{G}}} = \frac{1}{1+\gamma} - \frac{\gamma(1-\eta^*)}{(1+\gamma)\Delta} > 0, \tag{72}$$

$$\frac{\widehat{n_{MN}}}{\widehat{\overline{G}}} = \frac{\gamma(1-\eta)}{(1+\gamma)\Delta} \geq 0. \tag{73}$$

[28]The effect of this shock on $q^*_t(z^*_{F|X})$ can be given as $\frac{\widehat{q^*(z^*_{F|X})}}{\widehat{\overline{G}}} = -\frac{1-\eta}{2}\frac{\widehat{\varepsilon}}{\widehat{\overline{G}}} + \gamma\frac{\widehat{n^*_X}}{\widehat{\overline{G}}}$.

Eq.(72) shows that the effect of this shock on the number of foreign multinational firms among home-located final goods firms is positive, while Eq.(73) shows that the effect of this shock on the number of home multinational firms among foreign-located final goods firms is non-negative. This is because, for the former, this shock brings a larger increase in profits as a direct effect of the shock than it does an increase in entry costs through nominal exchange rate depreciation, while, for the latter, in a foreign country, it prevents the entry costs from increasing through nominal exchange rate depreciation (see Eqs.(59), (60) and (66)). Here, differentiating both Eqs.(72) and (73) with respect to η and η^*, we can show that a rise in η and/or η^* essentially intensifies the increase in the number of foreign multinational firms among home-located final goods firms, while a rise in η and/or η^* essentially weakens the increase in the number of home multinational firms among foreign-located final goods firms. These results are based on the fact that both the increase in entry costs in the home market and the decrease in entry costs in the foreign market are weakened through the weakening of nominal exchange rate depreciation. In another analysis, comparing the scenarios with and without vertical trade, we may be able to show that the number of foreign multinational firms among home-located final goods firms significantly increases, while the number of home multinational firms among foreign-located final goods firms significantly decreases in the latter. The explanation for the former is similar to the explanation for the fact that the number of domestic market and export firms among home-located final goods firms may increase significantly, while the explanation for the latter is similar to the explanation for the fact that the number of domestic market and export firms among foreign-located final goods firms may decrease significantly.

Finally, the number of different types of final goods firms in the long-run equilibrium are as follows:

$$\frac{\widehat{n_D}}{\widehat{G}} = \frac{\widehat{n_X}}{\widehat{G}} = \frac{\widehat{n_D^*}}{\widehat{G}} = \frac{\widehat{n_X^*}}{\widehat{G}} = \frac{\widehat{n_{MN}}}{\widehat{G}} = \frac{\widehat{n_{MN}^*}}{\widehat{G}} = \frac{1}{2(1+\gamma)} > 0. \tag{74}$$

Here, taking Eq.(67) into account, we obtain a relationship whereby the sum of the free entry conditions of two types of tradable goods firms selling in the home market is equal to that of the free entry conditions of two types of tradable goods firms selling in the foreign market. In addition, by combining this relationship with the two conditions of $\widehat{n_D} = \widehat{n_X^*}$ and $\widehat{n_D^*} = \widehat{n_X}$,[29] we also obtain that the number of four types of tradable goods firms is equal. Further, taking the free entry conditions of two types of multinational firms into account, we obtain Eq.(74) shown above. It is important to note that the number of domestic market firms among foreign-located final goods firms is certainly positive. In the short-run equilibrium, the entry costs of these firms have the potential to exceed their profits. However, in the long-run equilibrium, the profits of these firms certainly exceed their entry costs. Hence, there is an increase in the number of these firms. Comparing the scenarios with and without vertical trade, the number of six types of final goods firms will probably not be equal in the scenario without vertical trade: the number of three types of home-located final goods firms may increase significantly and the number of three types of foreign-located final goods firms may decrease significantly. The mechanism by which this outcome arises can be explained by the

[29] From Eqs.(64) and (65), these conditions are derived.

mechanism used in the analysis of short-run equilibrium.

3.2.3 Effects on CPI and overall consumption

This subsubsection examines the effects of a positive home government spending shock on the CPIs of both the countries and overall consumption in both countries. Let us first consider the effects of this shock on the CPIs of both the countries in the short-run equilibrium, which can be given as follows:

$$\frac{\widehat{P}}{\widehat{G}} = -\frac{\delta}{(1+\gamma)(\rho-1)} - \frac{1-\delta}{(1+\gamma)(\theta-1)} + \frac{\gamma\Omega_1}{2(1+\gamma)(\theta-1)(\rho-1)\Delta}, \tag{75}$$

$$\frac{\widehat{P^*}}{\widehat{G}} = -\frac{\gamma\Omega_2}{2(1+\gamma)(\theta-1)(\rho-1)\Delta} < 0, \tag{76}$$

where $\Omega_1 \equiv 2(1+\gamma)(1-\eta^*)(\rho-1)(\theta-1) + \delta(\theta-1)(2+\eta-\eta^*+(\eta+\eta^*)(1+\gamma)(\rho-1)) + 2(1-\delta)(\rho-1)(1-\eta^*) > 0$ and $\Omega_2 \equiv 2(1+\gamma)(1-\eta)(\rho-1)(\theta-1) + \delta(\theta-1)(2+\eta^*-\eta+(\eta+\eta^*)(1+\gamma)(\rho-1)) + 2(1-\delta)(\rho-1)(1-\eta) > 0$. Eq.(75) shows that the effect of this shock on home CPI in the short-run equilibrium is ambiguous, while Eq.(76) shows that the effect of this shock on foreign CPI in the short-run equilibrium is negative. Using the variables representing the nominal exchange rate and the number of different types of final goods firms, Eqs.(75) and (76) can be rewritten as follows:

$$\frac{\widehat{P}}{\widehat{G}} = -\left(\frac{\delta}{2(\rho-1)}\left(\frac{\widehat{n_D}}{\widehat{G}} + \frac{\widehat{n_X^*}}{\widehat{G}}\right) + \frac{1-\delta}{\theta-1}\frac{\widehat{n_{MN}^*}}{\widehat{G}}\right) + \frac{2(1-\eta^*)+\delta(\eta+\eta^*)}{4}\frac{\widehat{\varepsilon}}{\widehat{G}}, \tag{77}$$

$$\frac{\widehat{P^*}}{\widehat{G}} = -\left(\frac{\delta}{2(\rho-1)}\left(\frac{\widehat{n_D^*}}{\widehat{G}} + \frac{\widehat{n_X}}{\widehat{G}}\right) + \frac{1-\delta}{\theta-1}\frac{\widehat{n_{MN}}}{\widehat{G}}\right) - \frac{2(1-\eta)+\delta(\eta+\eta^*)}{4}\frac{\widehat{\varepsilon}}{\widehat{G}}. \tag{78}$$

From Eqs.(77) and (78), Eqs.(75) and (76) can be explained as follows. To begin with, the home country result can be explained by way of two channels: the increase in the weighted sum of the number of three types of final goods firms that sell in the home market; and the depreciation of the nominal exchange rate. The effect of the first channel on home CPI in the short-run equilibrium is brought about by an increase in the supply of final goods sold in the home country. The effect of the second channel on home CPI in the short-run equilibrium is brought about by an increase in the home-currency prices of home final goods sold in the home country and an increase in the home price index of final tradable goods due to a deterioration in the terms of trade of the home country. Consequently, the overall effect of this shock on home CPI in the short-run equilibrium is ambiguous. Next, the foreign country result can be also explained by way of two channels: the increase in the weighted sum of the number of three types of final goods firms that sell in the foreign market; and the depreciation of the nominal exchange rate. The effect of the first channel on foreign CPI in the short-run equilibrium is brought about by an increase in the supply of final goods sold in the foreign country. The effect of the second channel on foreign CPI in the short-run equilibrium is brought about by a

decrease in the foreign-currency prices of foreign final goods sold in the foreign country and a decrease in the foreign price index of final tradable goods due to an improvement in the terms of trade of the foreign country. Consequently, the overall effect of this shock on foreign CPI in the short-run equilibrium is negative. This is determined independent of home and foreign LCP parameters. Here, a rise in η^* weakens the increase in (or intensifies the decrease in) home CPI, and a rise in η weakens the decrease in foreign CPI. In particular, the latter result can be explained by the decline in the degree of the decrease in the two channels on foreign CPI due to the rise in η. In addition, our model can also handle fluctuations in home-currency (foreign-currency) prices of home (foreign) final goods sold in the home (foreign) country. This is a key feature of our model, which introduces vertical trade. Furthermore, comparing the scenarios with and without vertical trade, we may be able to show an increase in downward pressure on home CPI, while we may be able to show a decrease in downward pressure on foreign CPI in the latter. This is based on the fact that, with regard to home CPI, there may be a greater increase in the number of domestic market firms and foreign multinational firms among home-located final goods firms, while with regard to foreign CPI, there may be a greater decrease in the number of domestic market firms and home multinational firms among foreign-located final goods firms.

In the long-run equilibrium, the effects of this shock on the CPIs of both the countries are as follows:

$$\frac{\widehat{P}}{\widehat{G}} = \frac{1}{2}\left(1 - \frac{\delta}{(\rho-1)(1+\gamma)} - \frac{1-\delta}{(\theta-1)(1+\gamma)}\right), \tag{79}$$

$$\frac{\widehat{P^*}}{\widehat{G}} = -\frac{1}{2}\left(1 + \frac{\delta}{(\rho-1)(1+\gamma)} + \frac{1-\delta}{(\theta-1)(1+\gamma)}\right) < 0. \tag{80}$$

Eq.(79) shows that the effect of this shock on home CPI is ambiguous, while Eq.(80) shows that its effect on foreign CPI is negative. The effect of this shock on home CPI is brought about by an increase in the supply of final goods sold in the home country and the increase in the home-currency prices of home final goods sold in the home country. On the other hand, the effect of this shock on foreign CPI is brought about by an increase in the supply of final goods sold in the foreign country and the decrease in the foreign-currency prices of foreign final goods sold in the foreign country. Compared with the CPIs in the short-run equilibrium, the CPIs in both countries are characterized by the disappearance of the terms of trade channel. The interpretation of the analysis comparing scenarios with and without vertical trade in the long-run equilibrium is the same as that for the short-run equilibrium analysis.

Next, let us consider the effects of a positive home government spending shock on overall home consumption $\widehat{C}(=-\widehat{P})$ and overall foreign consumption $\widehat{C^*}(=-\widehat{P^*})$. The effect of this shock on $\widehat{C}$ is ambiguous since its effect on home CPI is ambiguous. On the other hand, the effect of this shock on $\widehat{C^*}$ is positive since its effect on foreign CPI is always negative. Here, we consider the fluctuations in overall consumption in both countries from the perspective of LCP. From the definition of $\widehat{C}$, when the increase (or decrease) in home CPI weakens (or intensifies), the decrease (or increase) in $\widehat{C}$ weakens (or intensifies). From the definition of $\widehat{C^*}$, when the decrease in foreign CPI weakens, the increase in $\widehat{C^*}$ weakens. Moreover, we consider

fluctuations in overall consumption in both countries by comparing the scenarios with and without vertical trade. In the scenario without vertical trade, there is likely to be greater downward pressure on home CPI, so overall home consumption is more likely to increase than in the scenario with vertical trade. On the other hand, in the scenario without vertical trade, there is likely to be smaller downward pressure on foreign CPI, so overall foreign consumption is more likely to decrease than in the scenario with vertical trade.

The variables $\widehat{\overline{C}}$ and $\widehat{\overline{C^*}}$, which are the long-run effects of this shock on overall consumption in the home and foreign countries, also fluctuate in the same direction as short-run effects. These fluctuations are determined based on the definition of consumption and the fluctuation of the CPI. The interpretation of the analysis comparing scenarios with and without vertical trade in the long-run equilibrium is the same as that for the short-run equilibrium analysis.

3.2.4 Effects on employment

This subsubsection examines the effects of a positive home government spending shock on the employment levels of both countries. Let us first consider the effects of this shock on the employment levels of both countries in the short-run equilibrium, which are as follows:

$$\frac{\widehat{\ell}}{\widehat{\overline{G}}} = \frac{1}{2}\left(1 + \frac{\gamma(2\theta(1-\eta) - (2-\eta-\eta^*))}{\theta\Delta}\right) > 0, \tag{81}$$

$$\frac{\widehat{\ell^*}}{\widehat{\overline{G}}} = \frac{1}{2}\left(1 - \frac{\gamma(2\theta(1-\eta^*) - (2-\eta-\eta^*))}{\theta\Delta}\right) > 0. \tag{82}$$

Eqs.(81) and (82) show that the effect of this shock on employment levels of both countries are positive. Using the variables that represent the number of different types of final goods firms, their profits, and the price indexes of intermediate goods imported by them, Eqs.(81) and (82) can be rewritten as follows:

$$\begin{aligned}\frac{\widehat{\ell}}{\widehat{\overline{G}}} = \frac{1}{2}\Bigg(&\frac{\delta}{2}\left(\sum_{j''=D,X}\frac{\widehat{n_{j''}}}{\widehat{\overline{G}}} + \sum_{j''=D,X}\frac{\widehat{n^*_{j''}}}{\widehat{\overline{G}}}\right) + (1-\delta)\left(\frac{\widehat{n^*_{MN}}}{\widehat{\overline{G}}} + \frac{\widehat{n_{MN}}}{\widehat{\overline{G}}}\right)\\
&+\frac{\delta}{2}\left(\sum_{j''=D,X}\frac{\widehat{\Pi_F(z_{F|j''})}}{\widehat{\overline{G}}} + \sum_{j''=D,X}\frac{\widehat{\Pi^*_F(z^*_{F|j''})}}{\widehat{\overline{G}}}\right) + (1-\delta)\left(\frac{\widehat{\Pi^*_F(z^*_{F|MN})}}{\widehat{\overline{G}}} + \frac{\widehat{\Pi_F(z_{F|MN})}}{\widehat{\overline{G}}}\right)\\
&-\frac{1}{2\theta}\left(\frac{\widehat{\tilde{P}_f}}{\widehat{\overline{G}}} + (2\theta-1)\frac{\widehat{\tilde{P}^*_h}}{\widehat{\overline{G}}}\right)\Bigg),\end{aligned} \tag{83}$$

$$\begin{aligned}\frac{\widehat{\ell^*}}{\widehat{\overline{G}}} = \frac{1}{2}\Bigg(&\frac{\delta}{2}\left(\sum_{j''=D,X}\frac{\widehat{n_{j''}}}{\widehat{\overline{G}}} + \sum_{j''=D,X}\frac{\widehat{n^*_{j''}}}{\widehat{\overline{G}}}\right) + (1-\delta)\left(\frac{\widehat{n^*_{MN}}}{\widehat{\overline{G}}} + \frac{\widehat{n_{MN}}}{\widehat{\overline{G}}}\right)\\
&+\frac{\delta}{2}\left(\sum_{j''=D,X}\frac{\widehat{\Pi_F(z_{F|j''})}}{\widehat{\overline{G}}} + \sum_{j''=D,X}\frac{\widehat{\Pi^*_F(z^*_{F|j''})}}{\widehat{\overline{G}}}\right) + (1-\delta)\left(\frac{\widehat{\Pi^*_F(z^*_{F|MN})}}{\widehat{\overline{G}}} + \frac{\widehat{\Pi_F(z_{F|MN})}}{\widehat{\overline{G}}}\right)\end{aligned}$$

$$-\frac{1}{2\theta}\left((2\theta-1)\frac{\widehat{\tilde{P}_f}}{\widehat{\overline{G}}}+\frac{\widehat{\tilde{P}_h^*}}{\widehat{\overline{G}}}\right). \tag{84}$$

As shown in Eqs.(83) and (84), the effects of this shock on the employment levels of both countries can be separated into three channels: the weighted sum of the number of three types of final goods firms located in both countries; the weighted sum of the profits of three types of final goods firms located in both countries; and the sum of the price indexes of intermediate goods imported by final goods firms located in both countries. From Eqs.(83) and (84), the mechanisms of these three channels can be explained as follows. To begin with, when the first and the second channels are positive, they cause an increase in intermediate goods required for the production of final goods. Therefore, they have a positive effect on the employment levels of both countries. On the other hand, when the third channel is negative, this is based on an increase in production costs of final goods. It, therefore, has a negative effect on the employment levels of both countries since it causes a decrease in intermediate goods used by final goods firms. Now, in both countries, the sum of the first and the second channels is positive. Additionally, the third channel in Eq.(83) shows that the demand for home intermediate goods by foreign final goods firms increases significantly due to the nominal exchange rate depreciation caused by this shock, while the third channel in Eq.(84) shows that the demand for foreign intermediate goods by home final goods firms decreases significantly for the same reason. Here, the third channel in Eq.(83) has a strong positive side. Therefore, the overall effect of this shock on the employment level of the home country is positive. On the other hand, although the third channel in Eq.(84) has a strong negative side, the positive effect due to the sum of the first and second channels dominates the whole. Therefore, the overall effect of this shock on the employment level of the foreign country is also positive. This is determined independently of home and foreign LCP parameters. Here, a rise in η weakens the increase in home employment, and a rise in η^* intensifies the increase in foreign employment.

In the long-run equilibrium with flexible prices in both the final and intermediate goods sectors, the effects of this shock on the employment levels of both countries can be given as follows:

$$\frac{\widehat{\bar{\ell}}}{\widehat{\overline{G}}}=\frac{2\theta-1}{2\theta}>0, \tag{85}$$

$$\frac{\widehat{\overline{\ell^*}}}{\widehat{\overline{G}}}=\frac{1}{2\theta}>0. \tag{86}$$

Eqs.(85) and (86) show that, as in the short-run equilibrium, the effects of this shock on the employment levels of both countries are positive. In addition, unlike in the case of the short-run equilibrium, the home country's third channel is clearly positive while the foreign country's third channel is clearly negative. Hence, the effect of this shock on home employment is greater than that on foreign employment.

Based on the results pertaining to short-run and long-run equilibriums, this shock has a persistent positive effect on employment levels in both countries over two periods.

3.2.5 Effects on aggregate output

This subsubsection examines the effects of a positive home government spending shock on the aggregate outputs of both countries. Let us first consider the effects of this shock on the aggregate outputs of both countries in the short-run equilibrium, which are as follows:

$$\frac{\widehat{Y}}{\widehat{G}} = \frac{\gamma + \gamma\eta^* + \rho(\eta + \eta^*) + \gamma(\rho - 1)(\eta + \eta^*)}{\Delta} > 0, \tag{87}$$

$$\frac{\widehat{Y^*}}{\widehat{G}} = \frac{\gamma(1 - \eta)}{\Delta} \geq 0. \tag{88}$$

Eq.(87) shows that the effect of this shock on aggregate home output is positive, while Eq. (88) shows that its effect on aggregate foreign output is non-negative. Using the variables that represent the numbers of different types of final goods firms, Eqs.(87) and (88) can be rewritten as follows:

$$\frac{\widehat{Y}}{\widehat{G}} = (1 + \gamma)\left(\frac{\delta}{2}\left(\frac{\widehat{n_D}}{\widehat{G}} + \frac{\widehat{n_X}}{\widehat{G}}\right) + (1 - \delta)\frac{\widehat{n^*_{MN}}}{\widehat{G}}\right) > 0, \tag{89}$$

$$\frac{\widehat{Y^*}}{\widehat{G}} = (1 + \gamma)\left(\frac{\delta}{2}\left(\frac{\widehat{n^*_D}}{\widehat{G}} + \frac{\widehat{n^*_X}}{\widehat{G}}\right) + (1 - \delta)\frac{\widehat{n_{MN}}}{\widehat{G}}\right) \geq 0. \tag{90}$$

As shown in Eq.(89), the effect of this shock on the weighted sum of the number of three types of home-located final goods firms is positive. This means that these firms increase their output of goods. On the other hand, as shown in Eq.(90), the effect of this shock on the weighted sum of the number of three types of foreign-located final goods firms is non-negative. This means that these firms, especially foreign final goods exporters and home multinational firms, also essentially increase their output of goods. However, when $\eta = 1$, this shock has no effect on aggregate foreign output. This is because it has no effect on the weighted sum of the number of three types of foreign-located final goods firms. Here, a rise in η and/or η^* essentially intensifies the increase in aggregate home output while weakening the increase in aggregate foreign output. These results can be explained by the fluctuation in the number of different types of final goods firms due to the rise in η and/or η^*. For example, a rise in η^* intensifies the increase in the number of each of the three types of home-located final goods firms. Therefore, the rise in this value intensifies the increase in aggregate home output.

By the way, the factor of firm entry plays a special role in the fluctuations in aggregate outputs in both countries. For example, a rise in the value of γ essentially weakens the increase in aggregate home output while intensifying the increase in aggregate foreign output. These can be explained as follows. When the value of γ rises, the three types of home-located final goods firms are less likely to enter the home market because their entry costs increase, while the three types of foreign-located final goods firms are more likely to enter foreign markets because their entry costs decrease.[30] These lower the output of final goods produced in the

[30]In accordance with what is noted in footnote 25, with regard to fluctuations in the number of final goods firms, the explanation here of an increase or a decrease in the entry costs for these firms due to a rise in γ is also based on a higher degree of nominal exchange rate depreciation due to the same.

home market and increase the output of final goods produced in the foreign market, thus weakening the increase in aggregate home output and intensifying the increase in aggregate foreign output. In addition, the factor of vertical trade also plays a special role in fluctuations in aggregate output in both countries. The fluctuation in aggregate home output may be significantly lower than in the scenario without vertical trade. As shown in Section 3.2.2, this is because, in the scenario with vertical trade, nominal exchange rate depreciation increases entry costs for the three types of home-located final goods firms, whereas, in the scenario without vertical trade, entry costs for these firms remain constant despite nominal exchange rate depreciation due to these firms not requiring imported foreign intermediate goods for market entry. That is, comparing the scenarios with and without vertical trade, the former has a greater potential to discourage the new entry of these firms into the home market than the latter, and hence also a greater potential to reduce the supply of goods by these firms. On the other hand, the fluctuation in aggregate foreign output may be significantly higher than in the scenario without vertical trade. As shown in Section 3.2.2, this is because, in the scenario with vertical trade, nominal exchange rate depreciation decreases entry costs for the three types of foreign-located final goods firms, whereas, in the scenario without vertical trade, entry costs for these firms also remain constant despite nominal exchange rate depreciation due to these firms not requiring imported home intermediate goods for market entry. That is, comparing the scenarios with and without vertical trade, the former has a greater potential to facilitate the new entry of these firms into the foreign market than the latter, and hence also a greater potential to increase the supply of goods by these firms.

Next, the long-run effects of this shock on aggregate outputs in the home and foreign countries are as follows:

$$\frac{\widehat{Y}}{\widehat{G}} = \frac{\widehat{Y^*}}{\widehat{G}} = \frac{1}{2} > 0.$$

From Eq.(74), the number of different types of final goods firms located in the home and foreign countries are all equally positive. Hence, from the long-run versions of Eqs.(89) and (90), the aggregate home output in the long-run equilibrium increases by the same levels as the aggregate foreign output in the long-run equilibrium.

Based on the results pertaining to short-run and long-run equilibriums, this shock essentially has a persistent positive effect on aggregate outputs in both countries over two periods. In particular, unlike the result of Cook and Devereux (2011), the fiscal spillover effect on aggregate foreign output in our analysis is shown to be positive, as in Devereux and Yu (2019) and Devereux et al. (2020).

4 Welfare

This section examines the effects of a positive home government spending shock on the welfare of both countries. Following Obstfeld and Rogoff (1995, 1996) and others, this paper focuses 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.[31] Taking the first-order approximation of the household's utility under such an assumption, we examine the effects of such a shock on the welfare of both countries $\left(\frac{dU^R}{\widehat{\widehat{G}}} = \frac{\widehat{C}}{\widehat{\widehat{G}}} - \frac{\sigma-1}{\sigma}\frac{\xi-1}{\xi}\frac{\widehat{\ell}}{\widehat{\widehat{G}}} + \frac{\beta}{1-\beta}\left(\frac{\widehat{\widehat{C}}}{\widehat{\widehat{G}}} - \frac{\sigma-1}{\sigma}\frac{\xi-1}{\xi}\frac{\widehat{\widehat{\ell}}}{\widehat{\widehat{G}}}\right)\right.$, $\left.\frac{dU^{*R}}{\widehat{\widehat{G}}} = \frac{\widehat{C^*}}{\widehat{\widehat{G}}} - \frac{\sigma-1}{\sigma}\frac{\xi-1}{\xi}\frac{\widehat{\ell^*}}{\widehat{\widehat{G}}} + \frac{\beta}{1-\beta}\left(\frac{\widehat{\widehat{C^*}}}{\widehat{\widehat{G}}} - \frac{\sigma-1}{\sigma}\frac{\xi-1}{\xi}\frac{\widehat{\widehat{\ell^*}}}{\widehat{\widehat{G}}}\right)\right)$. Effects on welfare are difficult to evaluate from an analytical perspective, so this paper evaluate them numerically, specifically by focusing on the degree of LCP. To perform an analysis using a numerical example, the values of seven parameters need to be specified. The parameters that measure the elasticities of substitution between any two differentiated final goods at the two stages of production are first set at $\theta = \sigma = 6$ in according with Gong et al. (2016).[32] The elasticity of substitution between goods produced in the home and foreign countries is set at $\rho = 4.5$ in accordance with Benigno and Benigno (2006). The elasticity of substitution among labor varieties is set at $\xi = 4.52$ in accordance with Gali (2013). The subjective discount factor is set at $\beta = 0.99$ in accordance with Ferrero (2009). The share of the tradable composite of differentiated final goods is set at $\delta = 0.25$ in accordance with Obstfeld and Rogoff (2005). Finally, γ is set somewhat arbitrarily at 1. In what follows, some speculations from the perspective of analytical investigation are introduced. This is followed by an analysis using a numerical example.

4.1 Analytical investigation

This subsection examines the effects of a positive home government spending shock on short-run welfare in both countries from the perspective of analytical analysis, since the LCP parameters only appear in the short-run equilibrium. Moreover, it is essentially unclear what the effect of this shock is on the short-run welfare of either country. Having said that, let us consider under what circumstances this shock raises or does not raise the levels of home and foreign short-run welfare. To begin with, it follows that this shock raises home short-run welfare as long as η and η^* meet the following condition:

$$\left(\theta\Gamma\left\{2\sigma\xi\{(\theta-1)\delta+(\rho-1)(1-\delta)\}-\Phi_1\right\}-\gamma(\theta-1)\left\{\theta\sigma\xi\delta(1+(\rho-1)(1+\gamma))-\Phi_2\right\}\right)\eta$$

$$+\left(\theta\Gamma\left\{2\sigma\xi\{(\theta-1)\delta+(\rho-1)(1-\delta)\}-\Phi_1\right\}+\theta\sigma\xi\gamma\left\{2(\rho-1)\{(\theta-1)(1+\gamma)+(1-\delta)\}\right.\right.$$

$$\left.\left.+\delta(\theta-1)(1-(\rho-1)(1+\gamma))\right\}-\gamma\Phi_1\right)\eta^*+\left(2\gamma\theta\sigma\xi\left\{(\rho-1)(1-\delta)-(\rho-1)(\theta-1)(1+\gamma)-\delta(\theta-1)\right\}\right.$$

[31] By abstracting from the utility of real balances, this paper follows the formulation of Obstfeld and Rogoff (1995, 1996). Many literatures pertaining to the NOEM model use this formulation. For e.g., see 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, 2018).

[32] A non-exhaustive list of contributions on estimates of these parameters, which correspond to a mark-up of 20 percent in the steady state, include Gali and Monacelli (2005, 2008), Gali (2008), Corsetti et al. (2011), and Farhi and Werning (2012).

$$-2\gamma(2\theta-1)\Phi_1+4\gamma\theta\sigma\xi(\theta-1)\delta\Big)>0, \tag{91}$$

where $\Gamma \equiv \gamma(\rho-1)+\rho > 0$, $\Phi_1 \equiv (\theta-1)(\rho-1)(\sigma-1)(\xi-1)(1+\gamma) > 0$ and $\Phi_2 \equiv (2\theta-1)(\rho-1)(\sigma-1)(\xi-1)(1+\gamma) > 0$.

On the other hand, when η and η^* satisfy the following condition, this shock lowers home short-run welfare:

$$\Bigg(\theta\Gamma\Big\{2\sigma\xi\{(\theta-1)\delta+(\rho-1)(1-\delta)\}-\Phi_1\Big\}-\gamma(\theta-1)\Big\{\theta\sigma\xi\delta(1+(\rho-1)(1+\gamma))-\Phi_2\Big\}\Bigg)\eta$$

$$+\Bigg(\theta\Gamma\Big\{2\sigma\xi\{(\theta-1)\delta+(\rho-1)(1-\delta)\}-\Phi_1\Big\}+\theta\sigma\xi\gamma\Big\{2(\rho-1)\{(\theta-1)(1+\gamma)+(1-\delta)\}$$

$$+\delta(\theta-1)(1-(\rho-1)(1+\gamma))\Big\}-\gamma\Phi_1\Bigg)\eta^*+\Bigg(2\gamma\theta\sigma\xi\Big\{(\rho-1)(1-\delta)-(\rho-1)(\theta-1)(1+\gamma)-\delta(\theta-1)\Big\}$$

$$-2\gamma(2\theta-1)\Phi_1+4\gamma\theta\sigma\xi(\theta-1)\delta\Big)<0. \tag{92}$$

Condition (91) shows that this shock causes the positive effect on short-run welfare from consumption of final goods to dominate the negative effect on short-run welfare from employment. On the other hand, condition (92) shows that this shock causes the negative effect on short-run welfare from employment to dominate the positive effect on short-run welfare from consumption of final goods. When $\eta = \eta^* = 0$, there is a high likelihood that the condition (92) will hold. This is because while the value of η^* is small, so that overall home consumption decreases significantly, or in the case it increases, the degree of the increase is small, the value of η is also small, so that home employment increases significantly. Now, when $\eta = \eta^* = 0$, condition (92) can be rewritten as follows:

$$1+\gamma > \frac{\theta\sigma\xi(\delta(\theta-1)+(1-\delta)(\rho-1))}{(\theta-1)(\rho-1)((2\theta-1)(\sigma-1)(\xi-1)+\theta\sigma\xi)}.$$

If this condition is satisfied and γ takes an extremely high value, this shock will greatly lower the short-run welfare of the home country. This can be explained as follows. When the value of γ is large, the entry costs for the three types of final goods firms selling in the home market become high. Hence, it becomes difficult for these firms to enter the final goods market of their respective countries. This causes a decline in the supply of goods by these firms in the home market, which intensifies (or weakens) the increase (or decrease) in home CPI. Therefore, the decrease (or increase) in overall home consumption intensifies (or weakens). Consequently, this shock greatly lowers the short-run utility of the home country.[33] On the other hand, if

[33]When the value of γ increases, the decrease (or increase) in overall home consumption in the long-run equilibrium also intensifies (or weakens). This can be explained by the same mechanism as that for an intensification in the decrease (or a weakening in the increase) in overall home consumption in the short-run equilibrium. Therefore, the mechanism for the effect of a change in the value of γ on the long-run welfare of the home country can be explained in the same way as in the short-run equilibrium.

we do not introduce vertical trade into our model, as shown in Section 3.2.3, a positive home government spending shock has the potential to raise overall home consumption to a greater degree than when we introduce vertical trade into the model, not only when $\eta = \eta^* = 0$. Consequently, this shock has the potential to significantly increase the short-run utility of the home country.[34]

Next, this shock raises foreign short-run welfare when η and η^* satisfy the following condition:

$$\Bigg(-\Phi_1(\theta\Gamma+\gamma(2\theta-1))+\gamma(\theta-1)\theta\sigma\xi\delta\Gamma\Bigg)\eta^*+\Bigg(-\theta\Bigg\{\Gamma\Phi_1+\sigma\xi\gamma\{2(\rho-1)\{(1-\delta)+(1+\gamma)(\theta-1)\}$$

$$+\delta(\theta-1)(2-\Gamma)\}\Bigg\}\Bigg)\eta+\Bigg(2\theta\sigma\xi\gamma\Bigg\{(\rho-1)\{(1+\gamma)(\theta-1)+(1-\delta)\}+\delta(\theta-1)\Bigg\}-2\gamma\theta\Phi_1\Bigg)>0. \quad (93)$$

On the other hand, when η and η^* satisfy the following condition, this shock lowers foreign short-run welfare:

$$\Bigg(-\Phi_1(\theta\Gamma+\gamma(2\theta-1))+\gamma(\theta-1)\theta\sigma\xi\delta\Gamma\Bigg)\eta^*+\Bigg(-\theta\Bigg\{\Gamma\Phi_1+\sigma\xi\gamma\{2(\rho-1)\{(1-\delta)+(1+\gamma)(\theta-1)\}$$

$$+\delta(\theta-1)(2-\Gamma)\}\Bigg\}\Bigg)\eta+\Bigg(2\theta\sigma\xi\gamma\Bigg\{(\rho-1)\{(1+\gamma)(\theta-1)+(1-\delta)\}+\delta(\theta-1)\Bigg\}-2\gamma\theta\Phi_1\Bigg)<0. \quad (94)$$

Condition (93) shows that this shock causes the positive effect on short-run welfare from consumption of final goods to dominate the negative effect on short-run welfare from employment. On the other hand, condition (94) shows that this shock causes the negative effect on short-run welfare from employment to dominate the positive effect on short-run welfare from consumption of final goods. When $\eta = \eta^* = 0$, there is high likelihood that condition (93) will hold. This is because, while the value of η is small, so that overall foreign consumption increases significantly, the value of η^* is also small, so that foreign employment increases only slightly.

Here, judging only by the short-run equilibrium for now, under the condition (92), this shock can be regarded as a beggar-thyself policy in the sense that it lowers home welfare.

4.2 Numerical example

This subsection examines the effects of a positive home government spending shock. Before examining the effects of this shock on the welfare of both countries, let us examine the effects of this shock on the overall consumptions of both countries in the short-run and long-run equilibriums ($\widehat{C}$, $\widehat{C^*}$, $\widehat{\overline{C}}$ and $\widehat{\overline{C^*}}$) and on the employment levels of both countries in the short-run and long-run equilibriums ($\widehat{\ell}$, $\widehat{\ell^*}$, $\widehat{\overline{\ell}}$ and $\widehat{\overline{\ell^*}}$). These analyses adopt scenario (a) in Table 1 as the benchmark scenario.

[34] If we do not introduce vertical trade into our model, overall home consumption in the long-run equilibrium is also likely to be higher than if we introduce vertical trade into the model. This can be explained by the same mechanism as the possible increase in overall home consumption in the short-run equilibrium. Therefore, the possibility of an increase in the long-run utility of the home country can be explained in the same way as the possibility of an increase in the short-run utility of the home country.

[Insert Table 1 around here]

To begin with, the first and second rows in Table 1 show the effect of this shock on $\widehat{C}$ and $\widehat{C^*}$, respectively. In all scenarios, the effect of this shock on $\widehat{C^*}$ is positive. On the other hand, in scenarios other than (c) and (d), the effect of this shock on $\widehat{C}$ is negative. In scenario (a), the positive effect on $\widehat{C^*}$ is largest. This is because all of the intermediate goods firms employ PCP. When the value of η rises, this effect is significantly weakened compared with the benchmark scenario (compare scenario (a) with scenarios (b) and (d)). Similarly, in scenario (a), the negative effect on $\widehat{C}$ is largest. When the value of η^* rises, this effect is weakened (compare scenario (a) with scenarios (c) and (d)). Next, the third and fourth rows in Table 1 show the effect of this shock on $\widehat{\ell}$ and $\widehat{\ell^*}$, respectively. In all scenarios, the effects of this shock on $\widehat{\ell}$ and $\widehat{\ell^*}$ are positive. In addition, in scenario (a), the effect of this shock is largest on $\widehat{\ell}$ and smallest on $\widehat{\ell^*}$. This is also because all the intermediate goods firms employ PCP. When the value of η rises, the effect on $\widehat{\ell}$ is significantly weakened compared with the benchmark scenario (compare scenario (a) with scenarios (b) and (d)). On the other hand, when the value of η^* rises, the effect on $\widehat{\ell^*}$ is significantly intensified compared with the benchmark scenario (compare scenario (a) with scenarios (c) and (d)). The fifth and sixth rows in Table 1 show the effect of this shock on $\widehat{\overline{C}}$ and $\widehat{\overline{C^*}}$, respectively, while the seventh and eighth rows show its effect on $\widehat{\overline{\ell}}$ and $\widehat{\overline{\ell^*}}$, respectively. Each of these variables, having reached its steady-state value, takes the same value in all scenarios.

Let us examine the effects of a positive home government spending shock on the welfare of both countries. The nineth and tenth rows in Table 1 show the effect of this shock on home country utility and foreign country utility, respectively. In all scenarios in Table 1, the effect on the home country's utility is negative, but that on the foreign country's utility is positive. Therefore, all scenarios show that this shock has a beggar-thyself and prosper-thy-neighbor effect. These effects are weakened in scenarios $(b)-(d)$ compared with the benchmark scenario, albeit only slightly.

5 Conclusions

By incorporating the three factors of LCP, vertical production and trade, and endogenous entry by final goods firms into the standard NOEM model with nominal wage and price rigidities, this study has examined how a positive home government spending shock affects macroeconomic variables and welfare. Its main findings can be summarized as follows. First, an increase in the degree of LCP weakens the depreciation of the nominal exchange rate caused by this shock. Second, an increase in the degree of LCP magnifies the effect of this shock on the number of final goods firms located in the home and foreign countries. In particular, an increase in the degree of LCP essentially weakens the increase in the number of home multinational firms among foreign-located final goods firms and intensifies the increase in the number of foreign multinational firms among home-located final goods firms. Third, the effects of this shock on the employment levels of both countries are positive. When the degree

of LCP increases, the effect of this shock on home employment is essentially weakened, while its effect on foreign employment is essentially strengthened. Fourth, the effects of this shock on the aggregate outputs of both countries are essentially positive. When the degree of LCP increases, the effect of this shock on aggregate home output is essentially strengthened, while its effect on aggregate foreign output is essentially weakened. Finally, the effect of this shock on home welfare is negative, while that on foreign welfare is positive. Therefore, this shock has a beggar-thyself and prosper-thy-neighbor effect.

Based on the various above findings, the following points can be suggested. First, it can be said, based on the second finding above that, when the government's objective is to prevent the promotion of outward FDI, government spending should be made when the pricing of intermediate goods firms is largely based on LCP. Similarly, when the government's objective is to accelerate the promotion of inward FDI, government spending should be made under the same circumstances as above. Next, the fourth finding shows that the international transmission effect of a home government spending shock on aggregate foreign output is largely absent when the pricing of intermediate goods firms is largely based on LCP, so if the home government is only interested in expanding its own output, it should do so under this circumstance. Finally, the fifth finding shows that a government spending shock has a beggar-thyself effect in this model, so the implementation of such a policy must be carefully considered. However, such an effect is weakened when many intermediate goods firms employ LCP, so, other things being equal, a higher LCP ratio is preferable. Therefore, if it is necessary to implement such a policy, it is preferable to do so under such circumstances. Bacchetta and Wincoop (2005) point out that when the nominal exchange rate fluctuates, home firms are better off choosing PCP over LCP if the goods produced in the home country are fairly differentiated.[35] Therefore, when many intermediate goods firms employ PCP, such an effect is intensified. Therefore, in such an environment it is advisable to implement other economic policies, such as corporate tax reduction, as shown by Dohwa (2018).

This paper obtained the above findings by making some strong assumptions. It would be more desirable to find the various results by relaxing these assumptions. First, the study may yield more interesting results, for instance, if it were to adopt a model that accepts a trade balance imbalance. Second, like Corsetti et al. (2007), this study might yield different results if it were modified to assume that the government spends only on goods produced by domestic market final goods firms. These issues remain for future research.

Acknowledgements

In writing this paper, I received consistent encouragement from Shigeto Kitano, Ryuzo Miyao, and Masahiko Shibamoto, for which I would like to express my special thanks. I am also grateful to Masataka Eguchi, Katsufumi Fukuda, Taiji Hagiwara, Kohei Hasui, Daisuke Ida, Shingo Iokibe, Yutaka Kurihara, Eiji Okano, Kobe University seminar participants, and participants of the 2022 Japanese Society of Monetary Economics Autumn Meeting, Kobe

[35] In other words, they point out that if the goods produced in the home country are fairly homogeneous, home firms are better off choosing LCP over PCP.

University, for their helpful comments and suggestions. All the errors in this paper are my own.

References

Athukorala, P., Menon, J., 1994. Pricing to market behaviour and exchange rate pass-through in Japanese exports. The Economic Journal 104, 271-281.

Bacchetta, P., van Wincoop, E., 2005. A theory of the currency denomination of international trade. Journal of International Economics 67, 295-319.

Benigno, G., Benigno, P., 2006. Designing targeting rules for international monetary policy cooperation. Journal of Monetary Economics 53, 473-506.

Berger, W., 2006. International interdependence and the welfare effects of monetary policy. International Review of Economics and Finance 15, 399-416.

Bergin, P.R., Corsetti, G., 2008. The extensive margin and monetary policy. Journal of Monetary Economics 55, 1222-1237.

Betts, C., Devereux, M.B., 2000. Exchange rate dynamics in a model of pricing-to-market. Journal of International Economics 50, 215-244.

Bilbiie, F., Ghironi, F., Melitz, M., 2007. Monetary policy and business cycles with endogenous entry and product variety. NBER Macroeconomic Annual 22, 299-353.

Boug, P., von Brasch, T., Gappelen, Å., Hammersland, R., Hungnes, H., Kolsrud, D., Skretting, J., Strøm, B., Vigtel, T.C., 2023. Fiscal policy, macroeconomic performance and industry structure in a small open economy. Journal of Macroeconomics 76, 103524.

Calvo. G., 1983. Staggered prices in a utility-maximizing framework. Journal of Monetary Economics 12, 383-398.

Carré, M., Collard, F., Monetary union: A welfare based approach. European Economic Review 47, 521-552.

Caselli, P., 2001. Fiscal consolidation under fixed exchange rates. European Economic Review 45, 425-450.

Cavallari, L., 2010. Exports and foreign direct investments in an endogenous-entry model with real and nominal uncertainty. Journal of Macroeconomics 32, 300-313.

Cavallari, L., 2013. Firms' entry, monetary policy and the international business cycle. Journal of International Economics 91, 263-274.

Chu, H., 2005. Welfare and public policy: The role of internationalized production. Economic

Inquiry 43, 542-557.

Clancy, D., Jacquinot, P., Lozej, M., 2016. Government expenditure composition and fiscal policy spillovers in small open economies within a monetary union. Journal of macroeconomics 48, 305-326.

Cook, D., Devereux, M.B., 2011. Optimal fiscal policy in a world liquidity trap. European Economic Review 55, 443-462.

Corsetti, G., Dedola L., 2005. A macroeconomic model of international price discrimination. Journal of International Economics 67, 129-155.

Corsetti, G., Dedola L., Leduc, S., 2011. Optimal monetary policy in open economies. In: Friedman, B.M., Woodford, M., (Eds.), Handbook of Monetary Economics 3, Elsevier, Philadelphia, PA, pp.861-934.

Corsetti, G., Pesenti, P., Roubini, N., Tille, C., 2000. Competitive devaluations: Toward a welfare-based approach. Journal of International Economics 51, 217-241.

Corsetti, G., Pesenti, P., 2001. Welfare and macroeconomic interdependence. The Quarterly Journal of Economics 116, 421-446.

Corsetti, G., Pesenti, P., 2005. International dimensions of optimal monetary policy. Journal of Monetary Economics 52, 281-305.

Corsetti, G., Martin, P., Pesenti, P., 2004. The home market effect and the international transmission mechanism. 2004 meeting papers 132, Society for Economic Dynamics.

Corsetti, G., Martin, P., Pesenti, P., 2007. Productivity, terms of trade and the 'home market effect'. Journal of International Economics 73, 99-127.

Corsetti, G., Martin, P., Pesenti, P., 2013. Varieties and the transfer problem. Journal of International Economics 89, 1-12.

Devereux, M.B., Engel, C., 2003. Monetary policy in the open economy revisited: Price setting and exchange-rate flexibility. Review of Economic Studies 70, 765-783.

Devereux, M.B., Yu, C., 2019. Models of international fiscal spillovers. Economics Letters 175, 76-79.

Devereux, M.B., Gente, K., Yu, C., 2020. Production networks and international fiscal spillovers. Working Paper No.28149.

Dixit, A.K., Stiglitz, E.J., 1977. Monopolistic competition and optimum product diversity. American Economic Review 67, 297-308.

Dohwa, K., 2008. The international transmission effect of monetary policy based on "the new open-economy macroeconomics": A three-country model of the US, Japan and ANIES assuming dollar-denominated transactions (in Japanese, with an English summary). Economic review (Keizai Kenkyu) 59, 30-45.

Dohwa, K., 2014. Welfare effects of monetary policy in an economy with vertical production and trade: An analysis based on the perspective of local currency pricing. Economic Modelling 41, 408-420.

Dohwa, K., 2018. The role of local currency pricing in international transmission effects of corporate tax reduction in an economy with vertical production linkage and foreign direct investment. MPRA Paper 106382.

ECU Institute., 1995. International currency competition and the future role of the single european currency. Kluwer Law International, London.

Farhi, E., Werning, I., 2012. Dealing with the trilemma: optimal capital controls with fixed exchange rates. NBER Working Paper No.18199.

Feenstra, R.C., 1998. Integration of trade and disintegration of production in the global economy. Journal of Economics Perspectives 12, 31-50.

Ferrero, A., 2009. Fiscal and monetary rules for a currency union. Journal of International Economics 77, 1-10.

Fujiwara, I., Ueda, K., 2013. The fiscal multiplier and spillover in a global liquidity trap. Journal of Economic Dynamics and Control 37, 1264-1283.

Gagnon, J.E., Knetter, M.M., 1995. Markup adjustment and exchange rate fluctuations: Evidence from panel data on automobile exports. Journal of International Money and Finance 14, 289-310.

Gali, J., 2008. Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework. Princeton University Press, Princeton.

Gali, J., 2013. Notes for a new guide to keynes (i): wages, aggregate demand, and employment. Journal of the European Economic Association 11 (5), 973-1003.

Gali, J., Monacelli, T., 2005. Monetary Policy and exchange rate volatility in a small open economy. Review of Economic Studies 72, 707-734.

Gali, J., Monacelli, T., 2008. Optimal monetary and fiscal policy in a currency union. Journal of International Economics 76, 116-132.

Ganelli, G., 2003. Useful government spending, direct crowding-out and fiscal policy interdependence. Journal of International Money and Finance 22, 87-103.

Ganelli, G., 2005a. The new open economy macroeconomics of government debt. Journal of International Economics 65, 167-184.

Ganelli, G., 2005b. Home bias in government spending and quasi neutrality of fiscal shocks. Macroeconomic Dynamics 9, 288-294.

Ganelli, G., Tervala, J., 2010. Public infrastructures, public consumption, and welfare in a new-open-economy-macro model. Journal of Macroeconomics 32, 827-837.

Ghironi, F., Melitz, M.J., 2005. International trade and macroeconomic dynamics with heterogeneous firms. The Quarterly Journal of Economics 120, 865-915.

Goldberg, L., Tille, C., 2009. Macroeconomic interdependence and the international role of the dollar. Journal of Monetary Economics 56, 990-1003.

Gong, L., Wang, C., Zou H.F., 2016. Optimal monetary policy with international trade in intermediate inputs. Journal of International Money and Finance 65, 140-165.

Gopinath, G., Boz, E., Casas, C., Díez, F.J., Gourinchas, P-O., Plagborg-Møller, M., 2020. Dominant currency paradigm. American Economic Review 110, 677-719.

Gopinath, G., Rigobon, R., 2008. Sticky Borders. The Quarterly Journal of Economics 123, 531-575.

Huang, K.X.D., Liu, Z., 2006. Sellers' local currency pricing or buyers' local currency pricing: Does it matter for international welfare analysis? Journal of Economic Dynamics and Control 30, 1183-1213.

Huang, K.X.D., Liu, Z., 2007. Business cycles with staggered prices and international trade in intermediate inputs. Journal of Monetary Economics 54, 1271-1289.

Hummels, D., Ishii, J., Yi, K.M., 2001. The nature and growth of vertical specialization in world trade. Journal of International Economics 54, 75-96.

Johdo, W., 2013. Corporate tax reductions, cross-border ownership and welfare. The Japanese Economic Review 64, 484-503.

Johdo, W., 2015. Monetary policy, foreign welfare, and international firm mobility. International Journal of Economic Theory 11, 311-328.

Johdo, W., 2019. Fiscal Policy, Relocation of Firms, and the Exchange Rate. Seoul Journal of Economics 32, 397-419.

Johdo, W., Hashimoto, K., 2005. International relocation, the real exchange rate, and welfare. Journal of Economic Dynamics and Control 29, 1449-1469.

Knetter, M.M., 1993. International comparisons of pricing-to-market behavior. American Economic Review 83, 473-486.

Lewis, V., 2006. Macroeconomic fluctuations and firm entry: Theory and evidence. National Bank of Belgium Working Paper 103.

Lombardo, G., Sutherland, A., 2004. Monetary and fiscal interactions in open economies. Journal of Macroeconomics 26, 319-347.

Marston, R.C., 1990. Pricing to market in Japanese manufacturing. Journal of International Economics 29, 217-236.

Melitz, M.J., 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica 71, 1695-1725.

Michaelis, J., 2006. Optimal monetary policy in the presence of pricing-to-market. Journal of Macroeconomics 28, 564-584.

Obstfeld, M., Rogoff, K., 1995. Exchange rate dynamics redux. Journal of Political Economy 103, 624-660.

Obstfeld, M., Rogoff, K., 1996. Foundations of International Macroeconomics, Chapter 10, MIT Press.

Obstfeld, M., Rogoff, K., 2000. New directions for stochastic open economy models. Journal of International Economics 50, 117-153.

Obstfeld, M., Rogoff, K., 2002. Global implications of self-oriented national monetary rules. The Quarterly Journal of Economics 117, 503-535.

Obstfeld, M., Rogoff, K., 2005. Global current account imbalances and exchange rate adjustments. Brooking Papers on Economic Activity 1, 67-147.

Parsley, D.C., 1993. Exchange rate pass-through: Evidence from aggregate Japanese exports. Southern Economic Journal 60, 454-462.

Pierdzioch, C., 2004. Capital mobility and the effectiveness of fiscal policy in open economies. Journal of Macroeconomics26, 465-479.

Russ, K.N., 2007. The endogeneity of the exchange rate as a determinant of FDI: A model of entry and multinational firms. Journal of International Economics 71, 344-372.

Shi, K., Xu, J., 2007. Optimal monetary policy with vertical production and trade. Review of International Economics 15, 514-537.

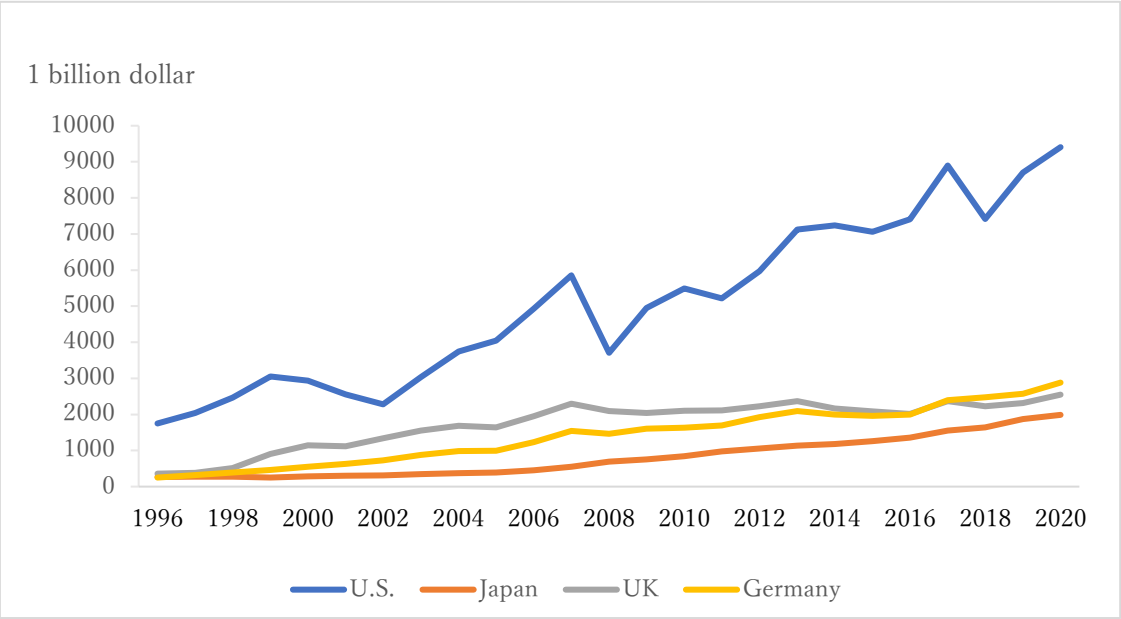
Sutherland, A., 2004. International monetary policy coordination and financial market integration. CEPR Discussion Papers 4251.

Tille, C., 2001. The role of consumption substitutability in the international transmission of monetary shocks. Journal of International Economics 53, 421-444.

Wei, S.J., Xie, Y., 2020. Monetary policy in an era of global supply chains. Journal of International Economics 124, Article 103299.

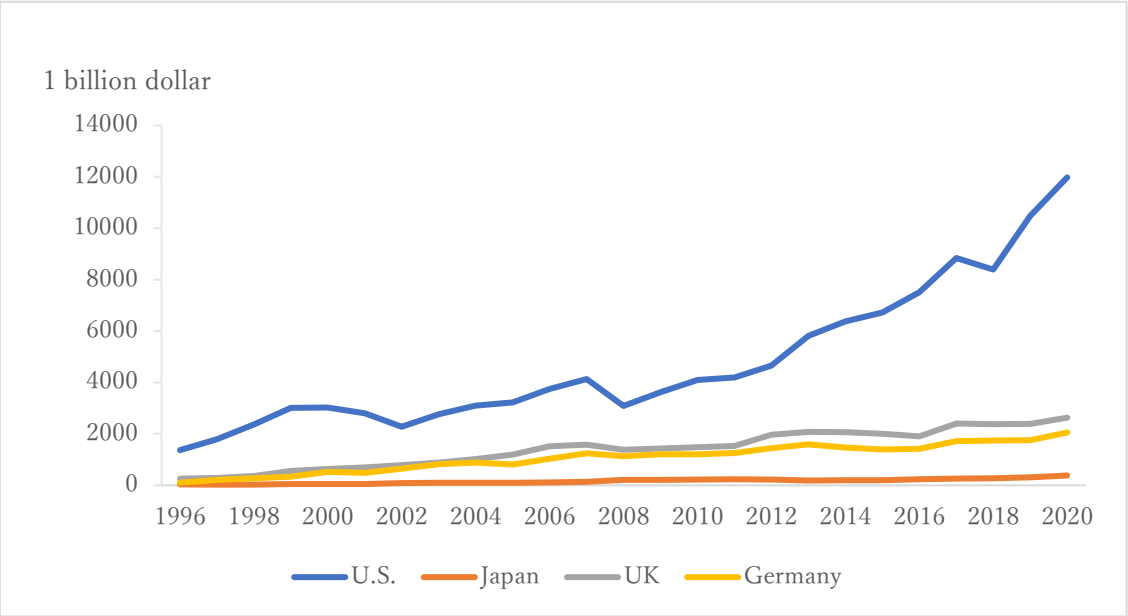
Yi, K.M., 2003. Can vertical specialization explain the growth of world trade? Journal of Political Economy 111, 52-102.

Fig. 1 Outward FDI from the U.S., Japan, the UK, and Germany.



Source: International Financial Statistics, IMF.

Fig. 2 Inward FDI to the U.S., Japan, the UK, and Germany.



Source: International Financial Statistics, IMF.

Table 1: Effects of a positive home government spending shock.

	$(a)\ \eta = \eta^* = 0$	$(b)\ \eta = 1,\ \eta^* = 0$	$(c)\ \eta = 0,\ \eta^* = 1$	$(d)\ \eta = \eta^* = 1$
$\widehat{C}$	−0.445	−0.015	0.096	0.095
$\widehat{C^*}$	0.555	0.014	0.125	0.016
$\widehat{\ell}$	0.917	0.492	0.592	0.500
$\widehat{\ell^*}$	0.083	0.408	0.508	0.500
$\widehat{\overline{C}}$	−0.445	−0.445	−0.445	−0.445
$\widehat{\overline{C^*}}$	0.555	0.555	0.555	0.555
$\widehat{\overline{\ell}}$	0.917	0.917	0.917	0.917
$\widehat{\overline{\ell^*}}$	0.083	0.083	0.083	0.083
dU^R	−103.953	−103.247	−103.201	−103.143
dU^{*R}	50.128	49.376	49.422	49.318