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On the equivalence and nonequivalence of import subsidies and export subsidies

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Abstract. *The purpose of this paper is to verify whether the Lerner symmetry theorem holds for export subsidies and import subsidies in an endogenous growth model with international location of manufactures. In this paper, we show that the Lerner symmetry theorem, which states that a country's export subsidies and import subsidies have the same resource allocation effect, does not hold in the aspects of international manufacture mobility and world economic growth rate. In particular, in contrast to the Lerner symmetry theorem, we show that export subsidies and import subsidies in the same location have rather opposite effects in these two aspects.*

Keywords: import subsidies, export subsidies, Lerner symmetry theorem, location, growth.

JEL Classification: F13, F43, O31.

1. Introduction

In an era of accelerating globalization, driven by the transboundary relocation of manufactures and a global trend toward increased government involvement in domestic and international markets through industrial policy—under the pretext of protecting and nurturing domestic industries—it is crucial to understand the economic impact of industrial policy within a realistic framework. Recently, attention has been drawn to trade-related industrial policies, including tariffs, export restrictions, import quotas, and production subsidies. However, while the effects of import tariffs have been extensively studied in the field of international economics, those of government subsidy policies, such as export and import subsidies, have not. Even if they are the same type of subsidy, the purposes of export subsidies and import subsidies are very different, and each country uses and implements them based on its economic situation (such as the availability of mineral resources and the maturity of its industry). Export subsidies have been implemented in many countries, not only under the pretext of protecting domestic industries, but also primarily targeting products considered strategically important in industries that can leverage economies of scale. Examples include semiconductors, electric vehicles, steel, and aluminum. Import subsidies, on the other hand, are government subsidies for imports of goods with an absolute shortage, such as mineral resources (e.g., crude oil and copper), production materials (e.g., feed and fertilizer), and staple foodstuffs (Anderson et al., 2008). One example is China's subsidy for capital goods imports, which is already in force(1).

According to Lerner's (1936) symmetry theorem, the economic effects of export and import subsidies are explained in the same manner. Intuitively, a country's export subsidies cause a shift of inputs from domestic import industries to domestic export industries. This results in a contraction of the former and an expansion of the latter. Similarly, a country's import subsidies induce a redistribution of inputs from import industries to export industries through increased competition in import industries. This results in a contraction of domestic import industries and an expansion of export industries. Thus, Lerner's symmetry theorem predicts that import and export subsidies have the same economic effect in a model of perfect competition with no capital mobility due to their similar effects on relative prices.

However, many researchers have already shown that once capital mobility, imperfect competition and trade imbalances are introduced into the perfect competition model without capital mobility assumed by Lerner, Lerner's symmetry theorem breaks down. For example, Ray (1975) departed from Lerner's perfect competition model and considered the case of monopoly power in domestic production of imported goods, and showed that Lerner's symmetry theorem does not hold in such a model and that export taxes and import duties affecting the demand curve have an asymmetric effect on competition in domestic markets for imported goods. Blanchard (2009) also shows the possibility of trade imbalances by introducing international ownership into McKinnon's (1966) model from traditional trade theory, which assumes trade equilibrium, and shows that Lerner symmetry is not obtained when there is international investment(2). Furthermore, Costinot and

Werning (2019) reexamine Lerner's symmetry theorem within a broader, more contemporary framework. They introduce multinational firms, domestic ownership of foreign assets, and imperfect competition, all of which were absent from Lerner's original model. Unlike Ray (1975), Costinot and Werning demonstrate that Lerner's symmetry theorem remains robust in imperfectly competitive markets without multinational firms. However, they also reveal that the theorem may break down when multinational firms are considered(3).

In the current global economic situation, globalization has progressed to the point that manufacturers can more easily shift their production bases internationally. This global trend suggests that Lerner's symmetry theorem is becoming less applicable to export and import subsidies. Furthermore, previous research indicates that the theorem does not apply to economic growth models that consider the cross-border movement of manufacturing industries. This study aims to analyze export and import subsidies and demonstrate how the theorem breaks down within the framework of endogenous growth theory.

The primary conclusions of this study indicate that export subsidies and import subsidies within the same geographical location exert contradictory economic influences on these two dimensions of international manufacturing relocation and global economic growth rate. However, the present study demonstrates that the impact of import subsidies in a given location is equivalent to the impact of export subsidies in a foreign location. This study's contribution was its provision of findings regarding the equivalence of import and export subsidies in a modern growth model that considers imperfect competition, the transboundary of manufacturing, and transportation costs.

This paper is organized into the following sections. Section 2 outlines the model's features. Section 3 describes the steady-state equilibrium under global knowledge spillovers in the innovative research and development (R&D). Section 4 analyzes how a unilateral increase in import and export subsidies affects the location of manufactures under global spillovers. It also discusses the implications of this result for the Lerner symmetry theorem. Section 5 describes the steady-state equilibrium under local knowledge spillovers in the R&D. Section 6 examines the effects of increased import and export subsidies on the location of manufactures and the global growth rate under local knowledge spillovers. It also considers the influence of local knowledge spillovers and its implications for the Lerner symmetry theorem. Section 7 concludes the paper.

2. Model structure

This paper uses a two-location model that includes the home location and the foreign location. In this model, the mobility of manufactures across the two locations is assumed, unlike that of owners. The lifetime utility function of a representative household is defined as

$$U = \int_0^{\infty} \log\left(E(t)^{\beta} X(t)^{1-\beta}\right) e^{-\rho t} dt. \quad (1)$$

In the above utility function, $X(t)$ is the numeraire product and $E(t)$ is defined as

$$E(t) = \left(\int_{i=0}^{N(t)} E(i,t)^{1-1/\sigma}\, di\right)^{1/(1-1/\sigma)}, \sigma > 1. \quad (2)$$

In equation (2), $E(i,t)$ denotes the consumption spending of differentiated product i, $N(t)$ represents the total number of products that have been produced and differentiated in both home and foreign locations, and σ is the elasticity of substitution between any two products. The home government provides two types of subsidies in this model: an import subsidy (s_m) for products imported from abroad, and an export subsidy (s_x) for products exported from the home location. For simplicity, we assume that the foreign government only provides export subsidies, s_x^*, and does not provide import subsidies. Within this model, the asterisk is utilized to indicate variables associated with the foreign location. Additionally, we assume that the numeraire product is not subject to import or export subsidies. Furthermore, every household supplies one unit of labor to earn $w(t)$. The intertemporal budget constraint of each household is formulated as

$$\dot{K}(t) = r(t)K(t) + (1 - s_h^w)w(t) - \left(1 + s_h^D\right)D(t) - T(t), \quad (3)$$

where $K(t)$, $r(t)$, s_h^w, $w(t)$, s_h^D, $D(t)$ and $T(t)$ are used to denote equity holdings, the interest rate, the wage tax rate, the wage rate, the consumption tax rate, the value of expenditure, and the lump-sum tax levied by the government per capita to finance import and export subsidies, respectively. We also make the assumption that transportation costs for differentiated products between locations are iceberg costs τ ($\tau \geq 1$). The amount of spending in the home location, D, is expressed as follows:

$$D = X + \int_{i \in n} P(i)E(i)di + \int_{j \in n^*} (1 - s_m)(1 - s_x^*)\tau P^*(j)E(j)dj. \quad (4)$$

Equation (4) shows that there are n manufactures in the home location and n^* manufactures in the foreign location, and $n + n^* = N$. Moreover, $P(i)$ is the home price of a variety i, while $P^*(j)$ is its price in the foreign location. Each location's differentiated product price indices are then

$$P^E = \left(\int_{i \in n} P(i)^{1-\sigma} di + \int_{j \in n^*} \left((1 - s_m)(1 - s_x^*)\tau P^*(j)\right)^{1-\sigma} dj\right)^{1/(1-\sigma)}, \quad (5)$$

$$P^{E*} = \left(\int_{i \in n} \left((1 - s_x)\tau P(i)\right)^{1-\sigma} di + \int_{j \in n^*} P^*(j)^{1-\sigma} dj\right)^{1/(1-\sigma)}, \quad (6)$$

where P^E is the home price index, and P^{E*} is the foreign price index. In the differentiated products sector, a patent is required to start production, so this cost can be considered fixed. To finance this cost, each manufacture issues equities. Furthermore, production requires η units of labor. Choosing $P(i)$ to maximize profit yields the following result: $P(i) = w\eta\sigma/(\sigma - 1)$. Therefore, the profit of each manufacture (= $\Pi(i)$) is calculated as

$\Pi(i) = P(i)q(i) - W\eta q(i) = W\eta q(i)/(\sigma - 1)$, where $q(i)$ denotes the amount of output. On the other hand, the homogeneous product *X* is assumed to be produced using a linear technology with coefficient 1. It is also assumed that *X* is produced in both locations. Therefore, the wage rate in both locations is represented by $W = W^* = 1$, since the numeraire is the homogeneous product. Thus, $P = P^* = \eta\sigma/(\sigma - 1)$. For convenience, we define $\delta \equiv \tau^{1-\sigma} \in (0, 1)$. In the household's decision-making process, when presented with the options $E(i)$ and $E(j)$, conventional utility maximization allocates a fraction β of *D* to $E(i)$ and $E(j)$, while allocating the residual fraction $(1 - \beta)$ of *D* to *X*:

$$E(i) = \frac{(\sigma-1)}{\eta\sigma}\left(\frac{\beta D}{n+n^*(1-s_m)^{1-\sigma}(1-s_x^*)^{1-\sigma}\delta}\right),$$

$$E(j) = \frac{(\sigma-1)}{\eta\sigma}\left(\frac{\beta D(1-s_m)^{-\sigma}(1-s_x^*)^{-\sigma}\tau^{-\sigma}}{n+n^*(1-s_m)^{1-\sigma}(1-s_x^*)^{1-\sigma}\delta}\right), X = (1-\beta)D. \quad (7)$$

Here, *b* represents equity value and *r* represents the return on a riskless bond. Thus, a no-arbitrage condition in capital markets establishes $\eta q/(\sigma - 1) + \dot{b} = rb$ by considering $W = W^* = 1$ and $\Pi(i) = W\beta x(i)/(\sigma - 1)$. The intertemporal optimization problem is then solved. To accomplish this, we require the following Euler equation, which results from maximizing (1) subject to (3): $\dot{D}/D = \dot{D}^*/D^* = r - \rho$. Next, we determine the optimal scale of production of differentiated products and the optimal share of manufactures in the home location. To do this, we aggregate (7) over all households. This results in the market-clearing condition for q and q^*:

$$q = \frac{\beta L(\sigma-1)}{\eta\sigma}\left(\frac{D}{n+n^*(1-s_m)^{1-\sigma}(1-s_x^*)^{1-\sigma}\delta} + \frac{D^*(1-s_x)^{-\sigma}\delta}{n^*+n(1-s_x)^{1-\sigma}\delta}\right), \quad (8)$$

$$q^* = \frac{\beta L(\sigma-1)}{\eta\sigma}\left(\frac{D(1-s_m)^{-\sigma}(1-s_x^*)^{-\sigma}\delta}{n+n^*(1-s_m)^{1-\sigma}(1-s_x^*)^{1-\sigma}\delta} + \frac{D^*}{n^*+n(1-s_x)^{1-\sigma}\delta}\right). \quad (9)$$

In equations (8) and (9), we keep the amount of labor endowment, *L*, the same in both locations. A manufacture's neutral position in choosing between the home and foreign locations is defined by equal profitability in both locations, as illustrated by the equation: $\Pi = \Pi^*$. Thus, using the equations $\Pi = W\eta q/(\sigma - 1)$, $\Pi = \Pi^*$, and $W = W^* = 1$, we obtain that $q = q^*$. The next step is to define *F* and F^*. *F* will be the home capital stock, and F^* will be the foreign capital stock. The total capital stock, $F + F^*$, determines *N*: $F + F^* = N$. Equations (8), (9), $\Pi = \Pi^*$ and $n + n^* = N$ are solved to obtain the share of manufactures located in the home location, defined by ξ, for a given level of spending in each location:

$$\xi = \frac{n}{N} = \frac{[1-(1-s_m)^{-\sigma}(1-s_x^*)^{-\sigma}\delta]D - [1-(1-s_x)^{-\sigma}\delta](1-s_m)^{1-\sigma}(1-s_x^*)^{1-\sigma}\delta D^*}{\mathrm{M}}, \quad (10)$$

where

$\mathrm{M} = [1-(1-s_m)^{-\sigma}(1-s_x^*)^{-\sigma}\delta][1-(1-s_x)^{1-\sigma}\delta]D + [1-(1-s_x)^{-\sigma}\delta][1-(1-s_m)^{1-\sigma}(1-s_x^*)^{1-\sigma}\delta]D^*$. Each firm's output is determined as follows:

$$q = q^* = \beta L\left(\frac{\sigma-1}{\eta\sigma}\right)\frac{\mathrm{M}}{N}\left\{\frac{1-(1-s_m)^{-\sigma}(1-s_x^*)^{-\sigma}\delta(1-s_x)^{-\sigma}\delta}{[1-(1-s_m)^{1-\sigma}(1-s_x^*)^{1-\sigma}\delta(1-s_x)^{1-\sigma}\delta][1-(1-s_m)^{-\sigma}(1-s_x^*)^{-\sigma}\delta][1-(1-s_x)^{-\sigma}\delta]}\right\}. \quad (11)$$

This paper also assumes $F > F^*$, as an initial condition. This is based on Martin (1999) and Martin and Ottaviano (1999). This assumption implies that there are more manufactures in the home location than in the foreign location.

3. The case of global knowledge spillover

We assume that R&D occurs under a linear technology, in which invention activity is proportional to labor input. To understand why researchers do R&D, we value the design created through R&D as b. In this section, we adopt the same assumption as Martin and Ottaviano (1999): that local R&D contributes to knowledge spillovers, which increase worldwide R&D productivity as global public goods. Therefore, R&D costs are assumed to be inversely proportional to the number of manufactures in the world. The assumption is made that a researcher involved in R&D utilizes κ/N units of labor, irrespective of their location, due to the presence of global spillovers. So, when it's free to enter the R&D sector, the result is $b = \kappa/N$. Next, we present a steady state in which the growth rate of N and the parameter ξ are constant. The value of equity, b, is determined by $b = \kappa/N$. Thus, assuming a balanced growth path implies a decline in b at the rate $g = \dot{N}/N$. Moreover, the condition for a worldwide labor market to clear is as follows:

$$\kappa g + (1-\beta)L(D + D^*) + \beta L\left(\frac{\sigma-1}{\sigma}\right)\mathrm{MI} = 2L, \quad (12)$$

where

$$\mathrm{I} = \frac{1-(1-s_m)^{-\sigma}(1-s_x^*)^{-\sigma}\delta(1-s_x)^{-\sigma}\delta}{[1-(1-s_m)^{1-\sigma}(1-s_x^*)^{1-\sigma}\delta(1-s_x)^{1-\sigma}\delta][1-(1-s_m)^{-\sigma}(1-s_x^*)^{-\sigma}\delta][1-(1-s_x)^{-\sigma}\delta]}. \quad (13)$$

Since g and ξ are constant in the steady state, D and D^* must also be constant, according to equation (12). This yields $r = \rho$ from the equation $\dot{D}/D = \dot{D}^*/D^* = r - \rho$. Then, by substituting equation (11), $\dot{b} = -gb$, $b = \kappa/N$, and $r = \rho$ into the equation $\eta q/(\sigma - 1) + \dot{b} = rb$, and considering equation (12), the following growth rate for the world is obtained:

$$g = \frac{2L}{\kappa\sigma} - \frac{(1-\beta)L(D+D^*)}{\kappa\sigma} - \left(\frac{\sigma-1}{\sigma}\right)\rho. \quad (14)$$

The budget constraint equation for each location's government that leads to tax revenue neutrality is $s_h^w W + s_h^D D = s_m \tau n^* P^*(f)E(f) + s_x \tau n P(h)E^*(h)$ and $s_f^{w*} W^* + s_f^{D*} D^* = s_x^* \tau n^* P^*(f)E(f)$, respectively. As indicated above, the government budget constraint necessitates that the financing of import and export subsidies be supported by revenues derived from consumption and wage taxes. Thus, taking into account the government's budget constraint equation above, the amount of spending in each country in the steady state is as $D = 1 + \rho\kappa f/L$ and $D^* = 1 + \rho\kappa(1-f)/L$, where $f \equiv F/N$. Therefore, the

world expenditure is derived as $D + D^* = 2 + \rho\kappa/L$. Next, the growth rate is determined by equations (14) and $D + D^* = 2 + \rho\kappa/L$, as follows:

$$\mathrm{g} = \frac{1}{\sigma}\left(\frac{2\beta L}{\kappa} - \rho(\sigma - \beta)\right). \tag{15}$$

Therefore, the following results are obtained from (15):

$$\frac{\partial \mathrm{g}}{\partial s_m} = 0,\ \frac{\partial \mathrm{g}}{\partial s_x^*} = 0, \frac{\partial \mathrm{g}}{\partial s_x} = 0. \tag{16}$$

According to equation (16), the global growth rate is unaffected by locations' import or export subsidies. This is because the financial burden of import or export subsidies is counteracted by the government's budget constraints due to the neutrality of tax revenue. Furthermore, in this model, knowledge spillovers are considered international public goods. Consequently, the cost of R&D investment is the same in all locations because manufactures can immediately absorb foreign knowledge, regardless of their location. Therefore, R&D investment in each location is unaffected by the international movement of manufactures caused by import or export subsidies. Therefore, in our model, neither import nor export subsidies affect innovation in each location, nor do they affect the world growth rate.

4. Location effects under global knowledge spillover

In this section, we analyze how a unilateral increase in import and export subsidies affects the location of manufactures under the condition of global knowledge spillovers. By substituting equations $D = 1 + \rho\kappa f/L$ and $D^* = 1 + \rho\kappa(1 - f)/L$ into ξ, as defined by equation (10), we can derive

$$\xi = \frac{n}{N} = \frac{[1-(1-s_m)^{-\sigma}(1-s_x^*)^{-\sigma}\delta]\left(1+\frac{\rho\kappa f}{L}\right)-[1-(1-s_x)^{-\sigma}\delta](1-s_m)^{1-\sigma}(1-s_x^*)^{1-\sigma}\delta\left[1+\frac{\rho\kappa(1-f)}{L}\right]}{[1-(1-s_m)^{-\sigma}(1-s_x^*)^{-\sigma}\delta][1-(1-s_x)^{1-\sigma}\delta]\left(1+\frac{\rho\kappa f}{L}\right)+[1-(1-s_x)^{-\sigma}\delta][1-(1-s_m)^{1-\sigma}(1-s_x^*)^{1-\sigma}\delta]\left[1+\frac{\rho\kappa(1-f)}{L}\right]}. \tag{17}$$

According to equation (17), an increase in import subsidies by the home location has the following effect on the location of the manufacture in the home location:

$$\left.\frac{\partial \xi}{\partial s_m}\right|_{s_m=s_x=s_x^*=0} = -\frac{(1-\delta)^2\delta}{\mathrm{M}^2}\left\{\left[\sigma\left(1+\frac{\rho\kappa f}{L}\right)+(\sigma-1)(1-\delta)\right]\left(2+\frac{\rho\kappa}{L}\right)-\left[\sigma\left(1+\frac{\rho\kappa f}{L}\right)+(\sigma-1)\left(1+\frac{\rho\kappa(1-f)}{L}\right)\right]\left[1-\delta+\frac{\rho\kappa f}{L}-\delta\frac{\rho\kappa(1-f)}{L}\right]\right\} < 0. \tag{18}$$

Equation (18) shows that an increase in unilateral import subsidies in the home location decreases ξ. The explanation for this result is as follows: An increase in import subsidies

in the home location increases the sales of imported foreign products in the home location. This increases profits from exports to the home location for manufactures located in the foreign location. This creates an incentive for manufactures in the home location to relocate to the foreign location. As a result, manufactures move from the home location to the foreign location. Next, according to equation (17), an increase in export subsidies in the foreign location affects ξ as follows:

$$\left.\frac{\partial \xi}{\partial s_x^*}\right|_{s_m=s_x=s_x^*=0} = -\frac{(1-\delta)^2\delta}{M^2}\left\{\left[\sigma\left(1+\frac{\rho\kappa f}{L}\right)+(\sigma-1)(1-\delta)\right]\left(2+\frac{\rho\kappa}{L}\right)-\left[\sigma\left(1+\frac{\rho\kappa f}{L}\right)+(\sigma-1)\left(1+\frac{\rho\kappa(1-f)}{L}\right)\right]\left[1-\delta+\frac{\rho\kappa f}{L}-\delta\frac{\rho\kappa(1-f)}{L}\right]\right\}<0. \quad (19)$$

Equation (19) shows that a rise in export subsidies in the foreign location leads to a smaller share of manufactures in the home location. The reason for this outcome is explained below. A unilateral export subsidies increase in the foreign location has been demonstrated to increase the sales of imported foreign products in the home location. This suggests that there is a potential for an increase in profits from exports to the home location for manufactures located in the foreign location. This, in turn, fosters an incentive for domestic manufactures to relocate to the foreign location, thereby prompting manufactures to migrate from the home location to the foreign location. Next, according to equation (17), a rise in export subsidies in the home location has the following impact on ξ:

$$\left.\frac{\partial \xi}{\partial s_x}\right|_{s_m=s_x=s_x^*=0} = \frac{(1-\delta)^2\delta}{M^2}\left\{\sigma\delta\left(1+\frac{\rho\kappa(1-f)}{L}\right)\left(2+\frac{\rho\kappa}{L}\right)+\left[1+\frac{\rho\kappa f}{L}-\delta\left(1+\frac{\rho\kappa(1-f)}{L}\right)\right]\left[(\sigma-1)\left(1+\frac{\rho\kappa f}{L}\right)+\sigma\left(1+\frac{\rho\kappa(1-f)}{L}\right)\right]\right\}>0. \quad (20)$$

Equation (20) shows that a rise in export subsidies in the home location leads to a larger share of manufactures being located there. The explanation for this result is as follows. An export subsidies increase in the home location has been demonstrated to increase the sales of exported home products in the foreign location. This phenomenon suggests a potential increase in profits from exports to the foreign location for manufactures located in the home location. This fosters an incentive for foreign manufactures to relocate to the home location, thereby prompting manufactures to transition from the foreign location to the home location.

Equations (18) and (19) show that the effects of a rise in import subsidies in the home location and a unilateral increase in export subsidies in the foreign location on manufacture location are identical. In summary, the following equation is valid:

$$\left.\frac{\partial \xi}{\partial s_m}\right|_{s_m=s_x=s_x^*=0} = \left.\frac{\partial \xi}{\partial s_x^*}\right|_{s_m=s_x=s_x^*=0}. \quad (21)$$

Equations (18) and (20), on the other hand, demonstrate that unilateral increases in import and export subsidies in the home location have opposing effects. Therefore, the following equation is valid:

$$\frac{\partial \xi}{\partial s_m}\Big|_{s_m=s_x=s_x^*=0} \neq \frac{\partial \xi}{\partial s_x}\Big|_{s_m=s_x=s_x^*=0}. \tag{22}$$

Equation (21) illustrates that the effects on manufacturing locations resulting from an increase in import subsidies in the home location and an increase in export subsidies in the foreign location are equivalent. However, as equation (21) shows, the effects on manufacturing locations of a rise in import and export subsidies in the same country manifest an asymmetrical pattern.

As previously discussed, the Lerner symmetry theorem does not hold in the context of international manufacturing relocation within an endogenous growth model incorporating manufacturing relocation. However, the aforementioned findings demonstrate that the symmetry theorem is applicable to home location import subsidies and foreign location export subsidies, rather than to home location import subsidies and export subsidies.

5. The case of local knowledge spillover

In the context of local R&D spillovers, R&D-related knowledge is regarded as local public goods. It is further assumed that knowledge spillovers exclusively augment R&D productivity within the domestic location, without exerting any effect on the productivity of the foreign location. Consequently, in accordance with Martin and Ottaviano's (1999) model, this study posits that, under the context of local spillovers, the cost of R&D in a given location is inversely proportional to the number of existing manufactures in that location. Consequently, it is formulated that R&D activities employ κ/n units of labor in the home location and κ/n^* units in the foreign location. In this model, κ is a parameter that represents the productivity of the R&D sector, assumed to be constant across both locations. This suggests that if the number of manufactures in the home location differs from the number of manufactures in the foreign location, then R&D activity will be conducted in the location with the greater number of manufactures. In the model under consideration, a relatively larger capital stock in the home location than in the foreign location ($F > F^*$) results in higher real expenditures on differentiated goods in the home location than in the foreign location. Consequently, this results in economies of scale within the product sector, leading to greater manufacturing concentration in the home location compared to the foreign one. Therefore, the entirety of R&D activity is conducted within the home location, thereby influencing the global growth rate. The free entry of

manufactures into the R&D sector is characterized by $b = \kappa/n$. Consequently, b is determined by the free entry condition, $b = \kappa/N\xi$. Therefore, the balanced growth assumption indicates a decline in b at a rate of g, which is equivalent to the differential equation $g = \dot{N}/N = \dot{n}/n$. The following is a delineation of the prevailing conditions in the global labor market:

$$\kappa\frac{g}{\xi} + (1-\beta)L(D+D^*) + \beta L\left(\frac{\sigma-1}{\sigma}\right)\mathrm{MI} = 2L, \tag{23}$$

$$I = \frac{1-(1-s_m)^{-\sigma}(1-s_x^*)^{-\sigma}\delta(1-s_x)^{-\sigma}\delta}{[1-(1-s_m)^{1-\sigma}(1-s_x^*)^{1-\sigma}\delta(1-s_x)^{1-\sigma}\delta][1-(1-s_m)^{-\sigma}(1-s_x^*)^{-\sigma}\delta][1-(1-s_x)^{-\sigma}\delta]}.$$

Substituting (11), $\dot{b} = -gb$, $b = \kappa/N\xi$, and $r = \rho$ into the equation $\eta q/(\sigma-1) + \dot{b} = rb$, and considering (23), the following growth rate is obtained:

$$g = \frac{2L\xi}{\kappa\sigma} - \frac{(1-\beta)L\xi(D+D^*)}{\kappa\sigma} - \left(\frac{\sigma-1}{\sigma}\right)\rho. \tag{24}$$

Therefore, given each location's government budget constraint, $s_h^W W + s_h^D D = s_m\tau n^* P^*(f)E(f) + s_x\tau nP(h)E^*(h)$ and $s_f^{W*}W^* + s_f^{D*}D^* = s_x^*\tau n^* P^*(f)E(f)$, respectively, the amount of expenditure in each location in steady state is as $D = 1 + \rho\kappa f/\xi L$ and $D^* = 1 + \rho\kappa(1-f)/\xi L$, where $f \equiv F/N$. In this case, the global spending is determined as $D + D^* = 2 + \rho\kappa/\xi L$. The growth rate is subsequently derived from equations (24) and $D + D^* = 2 + \rho\kappa/\xi L$ as follows:

$$g = \frac{1}{\sigma}\left(\frac{2\beta L}{\kappa}\xi - \rho(\sigma-\beta)\right). \tag{25}$$

Substituting the equations $D = 1 + \rho\kappa f/\xi L$ and $D^* = 1 + \rho\kappa(1-f)/\xi L$ into ξ yields the following result.

$$\xi = \frac{n}{N} = \frac{[1-(1-s_m)^{-\sigma}(1-s_x^*)^{-\sigma}\delta]\left(1+\frac{\rho\kappa f}{\xi L}\right) - [1-(1-s_x)^{-\sigma}\delta](1-s_m)^{1-\sigma}(1-s_x^*)^{1-\sigma}\delta\left[1+\frac{\rho\kappa(1-f)}{\xi L}\right]}{[1-(1-s_m)^{-\sigma}(1-s_x^*)^{-\sigma}\delta][1-(1-s_x)^{1-\sigma}\delta]\left(1+\frac{\rho\kappa f}{\xi L}\right) + [1-(1-s_x)^{-\sigma}\delta][1-(1-s_m)^{1-\sigma}(1-s_x^*)^{1-\sigma}\delta]\left[1+\frac{\rho\kappa(1-f)}{\xi L}\right]}. \tag{26}$$

From equation (26), the following quadratic equation is obtained for ξ:

$$J_1\xi^2 + J_2\xi + J_3 = 0, \tag{27}$$

where

$$J_1 = L[1-(1-s_m)^{-\sigma}(1-s_x^*)^{-\sigma}\delta][1-(1-s_x)^{1-\sigma}\delta] + L[1-(1-s_x)^{-\sigma}\delta][1-(1-s_m)^{1-\sigma}(1-s_x^*)^{1-\sigma}\delta] > 0, \tag{28}$$

$$\begin{aligned}\mathrm{J}_2 = {} & \rho\kappa f[1-(1-\mathrm{s}_m)^{-\sigma}(1-\mathrm{s}_x^*)^{-\sigma}\delta][1-(1-\mathrm{s}_x)^{1-\sigma}\delta] + \\ & + \rho\kappa(1-f)[1-(1-\mathrm{s}_x)^{-\sigma}\delta][1-(1-\mathrm{s}_m)^{1-\sigma}(1-\mathrm{s}_x^*)^{1-\sigma}\delta] - \\ & - L[1-(1-\mathrm{s}_m)^{-\sigma}(1-\mathrm{s}_x^*)^{-\sigma}\delta] + \\ & + L[1-(1-\mathrm{s}_x)^{-\sigma}\delta](1-\mathrm{s}_m)^{1-\sigma}(1-\mathrm{s}_x^*)^{1-\sigma}\delta, \end{aligned} \tag{29}$$

$$\begin{aligned}\mathrm{J}_3 = {} & -\rho\kappa f[1-(1-\mathrm{s}_m)^{-\sigma}(1-\mathrm{s}_x^*)^{-\sigma}\delta] + \\ & + \rho\kappa(1-f)[1-(1-\mathrm{s}_x)^{-\sigma}\delta](1-\mathrm{s}_m)^{1-\sigma}(1-\mathrm{s}_x^*)^{1-\sigma}\delta < 0. \end{aligned} \tag{30}$$

For equation (29), when L is large, and ρ, κ, and δ, are small, we obtain

$$\mathrm{J}_2 < 0. \tag{31}$$

The positive root of the equation,

$$\xi = \frac{-\mathrm{J}_2+\sqrt{\mathrm{J}_2^2-4\mathrm{J}_1\mathrm{J}_3}}{2\mathrm{J}_1}, \tag{32}$$

is the solution that is valid.

6. Location and growth effects under local knowledge spillover

In this section, we examine how a unilateral increase in import and export subsidies affects the location of manufactures and the growth rate. Here, we take into account the influence of localized knowledge spillovers. We also assume that the conditions for the validity of (31) are met, meaning that L is large and ρ, κ, and δ are small. According to equation (32), the effects of increasing import subsidies in the home location and export subsidies in the foreign location are as follows:

$$\left.\frac{\partial\xi}{\partial \mathrm{s}_m}\right|_{\mathrm{s}_m=\mathrm{s}_x=\mathrm{s}_x^*=0} = \left.\frac{\partial\xi}{\partial \mathrm{s}_x^*}\right|_{\mathrm{s}_m=\mathrm{s}_x=\mathrm{s}_x^*=0} < 0. \tag{33}$$

The intuitive explanation of equation (33) is equivalent to those given in equations (18) and (19), assuming global spillovers. Next, according to equation (32), a unilateral increase in export subsidies by the home location affects ξ as follows:

$$\left.\frac{\partial\xi}{\partial \mathrm{s}_x}\right|_{\mathrm{s}_m=\mathrm{s}_x=\mathrm{s}_x^*=0} > 0. \tag{34}$$

The intuitive explanation of equation (34) is equivalent to that of equation (20), which assumes global spillovers. Therefore, based on equations (33) and (34), the Lerner symmetry theorem does not apply to the impact of international manufacture relocation in an endogenous growth model that includes manufacture relocation, even under localized R&D spillovers. In summary, in the context of local R&D spillovers, the symmetry theorem does not apply to import subsidies and export subsidies in the same location with respect to their impact on international manufacturing relocation. In the context of local R&D spillovers, the symmetry theorem finds application in the context of home import subsidies

and foreign export subsidies, with regard to their impact on international manufacturing relocation. These results are key to understanding the effects of unilateral increases in import and export subsidies on world growth under local knowledge spillovers, which will be examined below.

We then examine how an increase in import and export subsidies in each location affects the global growth rate by looking at how it impacts manufacture location under local knowledge spillovers. Using the results of (33) and (34), we differentiate (25) with respect to each location's import and export subsidies and arrive at the following results:

$$\frac{\partial g}{\partial s_m}\Big|_{s_m=s_x=s_x^*=0} = \frac{\partial g}{\partial s_x^*}\Big|_{s_m=s_x=s_x^*=0} < 0, \tag{35}$$

$$\frac{\partial g}{\partial s_x}\Big|_{s_m=s_x=s_x^*=0} > 0. \tag{36}$$

As mentioned earlier, the global growth rate is influenced by a location's R&D activity, provided there are local knowledge spillovers. According to equations (33) and (35), increasing import subsidies in the home location and export subsidies in the foreign location decreases the world growth rate by attracting home manufactures to the foreign location. Conversely, equations (34) and (36) show that increasing export subsidies in the home location positively affects the world growth rate by attracting foreign manufactures to the home location. Equations (35) and (36) demonstrate that the effects of an increase in import and export subsidies in the same location on world growth are asymmetric when local knowledge spillovers are considered. For these reasons, the Lerner symmetry theorem does not hold for the impact on the world growth rate in an endogenous growth model that includes manufacture relocation under the condition of local knowledge spillovers. In other words, in our model, the symmetry theorem holds not between a home location's import subsidies and export subsidies but between a home location's import subsidies and a foreign location's export subsidies.

7. Conclusion

In this study, an endogenous growth model that incorporates manufacturing location was employed to examine the validity of the equivalence of import and export subsidies in the context of international manufacturing relocation and global growth. Our analysis revealed that the Lerner symmetry theorem, which asserts that import and export subsidies within a location have identical economic consequences, is invalid in cases of international manufacturing relocation and global growth. Specifically, our model showed that import and export subsidies in the same location have opposite effects. However, we found that an equivalence relationship exists between home import subsidies and foreign export subsidies in all cases of international manufacturing relocation and world growth rates.

Notes

(1) Two empirical studies examining the effects of these subsidies on capital goods imports in China are Li et al. (2023) and Huang et al. (2023).

(2) McKinnon (1966) expanded upon Lerner's (1936) two-final-goods model by creating a model with three final goods. He compared the case with only a tariff to the case with an export tax and an import subsidy. This comparison showed that both cases were equivalent in terms of resource allocation. Thus, McKinnon simultaneously proved the robustness of Lerner's symmetry theorem.

(3) Additionally, the following studies have attempted to generalize the Lerner symmetry theorem: Yeh (1990), Casas (1991), Lapan and Gervais (2004), Francois and Manchin (2014), Lindé and Pescatori (2019), Azacis and Collie (2020), and Itskhoki and Mukhin (2023).

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