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Innovation, foreign direct investment and local content requirement*

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Abstract

This paper develops a model of North-South quality-ladder growth and foreign direct investment, and uses this model to examine how local content requirement by the Southern government affects innovation and welfare within a dynamic general equilibrium model. This paper shows that the relaxation of the local content requirement may result in higher prices of consumable goods, but this simultaneously promotes innovative activities in the North, which in turn accelerates the improvement of goods' qualities. This paper characterizes the condition under which the latter effect overcomes the former to improve welfare in both countries.

Keywords: foreign direct investment; endogenous innovation; local content requirement; quality-ladder growth.
JEL classfication: F21; F43; O32; O33

1. Introduction

Recently, under pressure from GATT/WTO, governments in developing countries have been obliged to eliminate a range of restrictions on foreign direct investment (FDI). Specifically, the Agreement on Trade-Related Investment Measures (the TRIMs agreement) under the Uruguay Round, in order to facilitate investment, prohibits some TRIMs including local content requirement (LCR) as a violation of GATT Art. III:4. However, it is unlikely that the TRIMs agreement has been strictly enforced. For example, although Art. V:2 of the TRIMs agreement states that developing countries were given a transition period of five years to start to implement their TRIMs obligations, 10 developing countries notified the WTO Council for Trade in Goods (CTG) of their TRIMs still to be eliminated, and submitted their requests to extend the transition period. As a result of the debate, the CTG decided to accept the requests from the countries for an extension of the deadline.[1] Furthermore,

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1) This decision is contained in Section 6.1 of "Implementation-Related Issues and Concerns" of the WTO's 2001 Ministerial Conference in Doha as the following text: (the TRIMs agreement) "[t]akes note of actions taken by the Council for Trade in Goods in regard to requests from some developing country-members for the extension of the five-year transi-

at the WTO's 2005 Ministerial Conference in Hong Kong (China), it was argued that for less developed countries, the deadline shall be extended by the CTG (WTO, 2005). These facts teach us that elimination of TRIMs seems to be one of its long-term objectives.[2]

Although the massive and rapid increase in FDI is one of the most striking phenomena, economic evaluations of LCR are surprisingly limited. Several researchers considered LCR in the context of static international trade theory. Under perfectly competitive markets for both final- and intermediate goods, Grossman (1981) systematically analyzed the effects of LCR on resource allocation, and this research was extended to the model of imperfect competition in intermediate goods markets (e.g., Krishna and Itoh, 1988) and final goods markets (e.g., Davidson et al., 1985; Lopez-de-Silanes et al., 1996). However, these papers did not investigate any welfare implications: i.e., they did not judge whether or not the developing countries should relax LCR. Furthermore, in these studies foreign firms' location choice is not introduced. Lahiri and Ono (1998), in contrast, tackled this problem in a two-country framework of Cournot oligopoly. They showed that the optimal LCR policy depends on the number of firms in the host country and the cost gap between firms in the host country and foreign country, as well as the endogenously determined number of foreign firms engaging in FDI.

Although the above literature gives important policy implications, it may overlook the role of FDI in technology transfer from developed- to developing countries. Using a cross-country regression involving 69 developing countries, Borensztein et al. (1998) emphasized that FDI by firms in developed countries is an important vehicle for the transfer of technology. They showed that FDI may contribute to growth relatively more than domestic investment in developing countries, unless the stock of human capital in the host country is sufficiently low. From a theoretical perspective, Helpman (1993, Sec. 4) and Lai (1998) respectively constructed North-South variety expansion models of exogenous and endogenous innovation, in both of which a change in the Southern government's IPR policy affects the Northern firms' FDI. By formulating North-South quality-ladder models, Glass and Saggi (2002), Glass and Wu (2007) and Futagami et al. (2009) also investigated the same topics.[3] Because

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tional period provided for in Article 5.2 of Agreement of Trade-related Investment Measures." (WTO, 2001). According to UNCTAD (2007), in consequence, an extension of the transition period was granted until the end of December 2003 for Argentina, Colombia, Mexico, Malaysia, Pakistan, Romania and Thailand, and until the end of June 2003 for the Philippines, on condition that these countries submit elimination plans and undergo status reviews.

2) Furthermore, under regional trade agreements such as the EU or NAFTA, the so-called "Rules of Origin" work in a similar way to the LCR. As Veloso (2006) reported, in the automobile industry, for example, content requirements in NAFTA account for 62.5% of component value. In the Mercosur and European regions, this value is 60%, while it is 45% in the ASEAN Free Trade Area.

3) Among others, Futagami et al. (2009) analytically investigated the effects of strengthening patent protection in the South on welfare in the North and the South, and showed that strengthening patent protection in the South can be Pareto-improving.

none of these studies has explored the implications of FDI-deterring policies such as LCR for innovation and technology transfer through FDI or welfare, these recent contributions motivate us to clarify the effects of LCR in a dynamic framework. The purpose of this paper is to examine analytically how growth and welfare are affected by LCR in a dynamic general equilibrium model.

This paper develops a model of North-South quality-ladder growth, where FDI is determined by firms' endogenous location choice of their assembly plants. Following most related studies, there is one primary factor, labor, in each country and the Southern labor is cheaper than the Northern labor. In the presented model, labor is used for production of both a single intermediate input and final goods. Thus, the final goods firms produce their output by using the input and labor. Following Grossman et al. (2006), we can interpret the latter use of labor as assembly activities. In order to examine the effects of LCR, this paper considers the situation where the intermediate input is cheaper in the North than in the South, which may be realistic as long as we focus on the developing countries that resist complying with the TRIMs agreement.[4] Because the final goods firms can choose the location of their assembly plants, if LCR were not imposed by the Southern government, they could choose the most profitable production process for themselves: e.g., they locate their plants in the South, import the input from the North and use the Southern labor for assembling. However, the Southern government imposes LCR on foreign firms such that the firms in the North that are shifting their plants to the South must buy at least a fixed proportion of total demand for the intermediate input from the local market: i.e., the Southern market. Obviously, this makes FDI less profitable for the Northern firms. Thus, as expected in reality, a relaxation of LCR triggers Northern firms' FDI in this model.

In this framework, the paper firstly shows that the relaxation of LCR by the Southern government promotes innovation activities in the North, but simultaneously weakens the domestic intermediate input sector. Then, from a positive point of view, this result seemingly suggests that there is a conflict between the Northern and Southern governments concerning whether or not to relax and/or abolish LCR. The Northern government, in order to promote domestic innovation activities, wants to continue the process of investment liberalization, whereas the Southern government wants to protect domestic industry that otherwise will suffer a decline as a direct result of abolishment of LCR. However, from a normative point of view, the welfare analysis in this paper shows the possibility of both countries agreeing to relax LCR.

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4) Needless to say, from a global point of view, now many firms in developed countries voluntarily outsource the production of intermediate goods to firms in developing countries: e.g., Chinese and Taiwanese firms. In order to focus on the role of LCR as an FDI barrier for developed countries and its implication for growth, this paper does not address the firms' voluntary outsourcing strategies, as Antràs and Helpman (2004) did.

The welfare effects of reducing the LCR consists of three parts: the growth effect, the price effect and the income effect. First, as stated above, reduction of LCR promotes innovation activities in the North, bringing about improving consumption qualities in the future. The second and third effects arise from a change in the wages in both countries. Because of an increase in R&D investment, the probability for leader firms to be overtaken by new firms rises. This makes the stock value of firms lower, which in turn makes the wage rate lower in the North through the free entry/exit condition for innovation activities. This implies that the income effect is negative for the Northern consumers. However, because of the reduction in LCR, FDI becomes more profitable and hence the wage rate in the South relative to that in the North increases. On the one hand, this places upward pressure on the labor income in the South. On the other hand, this may make the marginal cost of follower firms increase, which is transmitted to a leader firm's charging price through its limit pricing strategy. Thus, the price effect and the income effect combine to be negative for the Northern consumers, but to be generally ambiguous for the Southern consumers. Under free trade, however, the consumers in both countries can equally enjoy the growth effect. This paper analytically characterizes the conditions under which the first growth effect outweighs the other two possible negative effects and hence reducing the LCR is Pareto improving.

The remainder of the paper is organized as follows. Section 2 formulates the model. Section 3 characterizes the equilibrium of the economy. Section 4 examines the effects of LCR. Section 5 concludes.

2. The model

Consider a world that consists of two countries, called the North (denoted by N) and the South (denoted by S). The population size in country $i \in \{N, S\}$ is given by L_i, and households are not mobile between the two countries. The basic structure follows a standard quality-ladder growth model (e.g., Grossman and Helpman, 1991, Ch. 4): there is a continuum of industries with unit mass, and within each industry there are many goods differentiated by their qualities. The allocation of labor resources to innovative activities can push forward the quality frontier. As in many existing studies, the highest quality can be invented only in the North, and thus only the Northern labor is devoted to innovation activities.

The final goods are produced from labor and an intermediate input (e.g., a machine- and electronic component), and the input is produced from only labor under constant returns to scale technology and perfect competition. Although the firms can shift their production bases from the North to the South instantaneously without any set-up cost, the Southern government imposes an LCR on foreign firms such that the firms in the North that are shifting their plants to the South must buy at

least $\kappa \in [0, 1] \times 100\%$ percent of total demand for the intermediate input from the local market: i.e., the Southern market.

2.1 Households

The lifetime utility of the representative consumer living in $i \in \{N, S\}$ is defined as:

$$U_i = \int_0^\infty \exp(-\rho t)\ln u_{i,t}dt, \tag{1}$$

where $\rho > 0$ is the constant subjective discount rate, and $u_{i,t}$ is the instantaneous utility, being specified as:

$$\ln u_{i,t} = \int_0^1 \ln\left[\sum_{m \in \mathcal{M}_t(j)} (\lambda)^m x_{i,t}(m, j)\right]dj, \tag{2}$$

where $x_{i,t}(m, j)$ denotes the demand for good j of quality m at date t. Following the existing literature, I describe the index of quality as the infinitely countable number, $m \in \mathcal{M}_t \equiv \{1, 2, 3, ...\}$, and specify the quality m as λ^m for any industry $j \in [0, 1]$, where λ is assumed to be greater than unity. Thus, the degree of quality increment is identically given by λ for all industries. The consumer's intertemporal budget constraint is:

$$A_{i,0}+H_{i,0}+ \lim_{t \to \infty} A_{i,t}\exp\left(- \int_0^t r_\tau d\tau\right) = \int_0^\infty E_{i,t}\exp\left(- \int_0^t r_\tau d\tau\right)dt, \tag{3}$$

together with the no-Ponzi-game condition: $\lim_{t \to \infty} A_{i,t}\exp\left(- \int_0^t r_\tau d\tau\right) \geq 0$, the equality of which will be shown to hold later. In Eq. (3), $A_{i,0}$ and $H_{i,0}$ stand for the consumer's financial- and human wealth, respectively, the latter of which is given by:

$$H_{i,0} = \int_0^\infty w_{i,t}\exp\left(- \int_0^t r_\tau d\tau\right)dt, \tag{4}$$

where w_i is the wage rate in country i. In Eq. (3), the term $E_{i,t}$ represents the consumer's total expenditure over all goods as follows:

$$E_{i,t} = \int_0^1\left[\sum_{m \in \mathcal{M}_t(j)} p_t(m, j)x_{i,t}(m, j)\right]dj, \tag{5}$$

where $p_i(m, j)$ is the price of good j of quality m.

As is well established, the consumer's maximization problem can be broken down into the following two steps. In the first stage, the representative consumer determines the time profile of his/her expenditure $E_{i,t}$ across time so as to maximize the lifetime utility (1) subject to Eq. (3). In the second stage, at each point in time, he/she allocates his/her expenditure $E_{i,t}$ across industries, so as to maximize $u_{i,t}$ given in Eq. (2) subject to Eq. (5). Let $\bar{m}_t(j)$ denote the value of m for which the quality-adjusted consumer price of good j is the lowest: i.e., $\bar{m}_t(j) \equiv \arg\min_m \{p_t(m, j)/\lambda^m : m \in \mathcal{M}_t(j)\}$. Then, in the final step, the consumer allocates the demand for good $j \in [0, 1]$ across quality levels as follows:

$$x_{i,t}(m, j) = \begin{cases} \dfrac{E_{i,t}}{p_t(m, j)} & \text{if } m = \bar{m}_t(j), \\ 0 & \text{otherwise.} \end{cases} \tag{6}$$

Then, in the first step, from his/her intertemporal optimization, the consumer allocates the expenditure across time according to the following Euler equation and the transversality condition: $\dot{E}_{i,t}/E_{i,t} = r_t - \rho$ and $\lim_{t \to \infty} A_{i,t} \exp\left(-\int_0^t r_\tau d\tau\right) = 0$. Throughout the paper, the expenditure aggregated over the North and the South is taken as the numeraire such that $L_N E_{N,t} + L_S E_{S,t} \equiv 1 \, \forall \, t \geq 0$, which is combined with the Euler equation to make the interest rate equal the subjective discount rate: $r_t = \rho \, \forall \, t \geq 0$.

2.2 Firms

2.2.1 Production

The intermediate input is assumed to be competitively supplied. In country $i \in \{N, S\}$, θ_i units of labor are employed to produce one unit of input. Let q_i and Z_i respectively denote the price and supply of the input in country i. Then, the profit maximization yields the following set of first order conditions:

$$q_i \leq \theta_i w_i, \ Z_i \geq 0, \ Z_i(q_i - \theta_i w_i) = 0. \tag{7}$$

Eq. (7) says that perfect competition results in the component firms in country i earning zero profit if the component is produced there, which will be shown below to hold true in both countries because of the LCR. Hereafter, the value of θ_N is normalized to unity without any loss of generality:

$$\theta_N = 1, \ \theta_S = \theta.$$

Turning to the final goods sector, in each industry the firms are separated into two types by their quality of products: a leader firm and follower firms. A firm is called a leader firm if it has the ability to produce its product at the level of currently available highest quality. Otherwise, it belongs to follower firms. Because the innovative activities occur only in the North in this paper, the leader firms have been born in the North. In this model, however, the firms can select their location of production without any cost. Throughout the paper, as in related studies, it is assumed that $w_S \leq w_N$ holds in equilibrium. This implies that the firm engaging in FDI can use Southern labor, which is cheaper than Northern labor.[5]

On the other hand, the Southern government imposes LCR such that the leader firms shifting their location to the South must buy at least $\kappa \times 100\%$ percent of total demand for the intermediate input from the Southern market. Here it is assumed that θ is assumed to be large enough that $w_N \leq \theta w_S$: that is, $q_N \leq q_S$ holds in equilibrium.[6] Combining this assumption and the aforementioned one, $w_S \leq w_N$, we

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5) The assumption that the wage rate is cheaper in the South is made also in most related studies that construct dynamic general equilibrium models of North-South technology transfers not only via FDI, but also licensing (e.g., Yang and Maskus, 2001; Tanaka et al., 2007).

6) This assumption is made simply because if $q_N > q_S$, all firms would voluntarily buy the component from the Southern market irrespective of LCR. The assumption that the input is more expensive in the host country is widely used in a large body of literature that studies LCR.

focus on the following case:

$1/\theta \leq \omega \leq 1; \omega \equiv w_S/w_N.$

Accordingly, $\theta > 1$ is assumed. This implies that as long as this inequality holds, the firms engaging in FDI would prefer to use the intermediate input made in the North, but the firms must purchase the intermediate input from the local supplier at a proportion of $\kappa \times 100\%$. Then, for the firms engaging in FDI, the cost to buy z units of the intermediate input becomes $q_F z$, where:

$$q_F = (1-\kappa)q_N + \kappa q_S \geq q_N, \tag{8}$$

the equality of which holds true when $\kappa = 0$. Thus, because of LCR, the firms engaging in FDI face a higher input price in compensation for enjoying the cheaper labor cost in the South. The term $\kappa(q_S - q_N)$ in Eq. (8) captures this effect and this can be viewed as the cost of FDI. Note that it is a general property of LCR that it provides neither government revenue (as a tariff would) nor quota rents.[7]

The production technology is given by $f(z, l)$, where z and l respectively are the demand for the input and that for labor. As in Grossman et al. (2006), we can interpret this use of labor as assembly activities.[8] The function f is assumed to be increasing, concave, twice differentiable and linearly homogenous. Then, the unit cost of a leader firm in the North, denoted by c_N, is given by $c_N = c(q_N, w_N)$, where $c(q_N, w_N) \equiv \min_{a_N^Z, a_N^L} \{q_N a_N^Z + w_N a_N^L : 1 = f(a_N^Z, a_N^L)\}$. The function $c(\cdot, \cdot)$ satisfies increasing, concave, twice differentiable and linearly homogenous. a_N^Z and a_N^L respectively represent a Northern leader's demand for the input and labor per unit of output. In the same way, the unit cost of a leader firm engaging in FDI, denoted by c_F, is given by $c_F = c(q_F, w_S)$, where $c(q_F, w_S) \equiv \min_{a_F^Z, a_F^L} \{q_F a_F^Z + w_S a_F^L : 1 = f(a_F^Z, a_F^L)\}$. a_F^Z and a_F^L respectively represent the demand for the input and labor per unit of output by a leader firm engaging in FDI.[9]

Now we are in a position to explain the leader firms' pricing behaviors. Following Grossman and Helpman (1991, Ch. 4), it is assumed that all firms engage in price competition within each industry j, and that at each point in time, manufacturing procedures of the second highest quality are in the public domain for all follower firms to be able to produce without any innovative activities. Then, in each industry, the leader firm chooses a limit price such that it just keeps its rivals, who

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7) As is apparent from Eq. (8), this paper defines LCR in physical terms. Grossman (1981) distinguishes between LCR defined in physical terms and that defined in value terms to investigate their different impacts on the intermediate goods sector. In order to obtain tractability of analysis, this paper uses LCR defined in physical terms.

8) For simplicity, this paper does not assume any heterogeneity in firms' productivity level, as Grossman et al. (2006) did.

9) More formally, the firms engaging in FDI minimize their unit cost, $q_N a_F^{ZN} + q_S a_F^{LS} + w_S a_F^L$, subject to $1 = f(a_F^Z, a_F^L)$ and $a_F^{ZS} \geq \kappa a_F^Z$, where a_F^{ZN} and a_F^{ZS} respectively denote demand for the Northern-made input and that for the Southern-made input. An LCR constraint is given by $a_F^{ZS} \geq \kappa a_F^Z$. Because $q_N \leq q_S$, this constraint is always binding, $a_F^{ZS} = \kappa a_F^Z$ holds and thus the unit cost of firms engaging in FDI is given by $c(q_F, w_S)$.

are able to manufacture the product that is one step behind on the quality ladder, from earning a positive profit from production. Let p_N and p_F respectively denote the price charged by the leader firm when it stays in the North and when it engages in FDI. From Eq. (6), it is found that the leader firm, irrespective of its location choice, chooses a price equal to the quality increment, λ, times its nearest rival's marginal cost in order to monopolize its industry. Then, who is the nearest rival? Throughout the paper, it is assumed that the Southern government imposes LCR in a discriminated manner. More specifically, the Southern government imposes LCR only on firms engaging in FDI. Therefore, there are potentially three kinds of followers: the Northern followers, FDI followers and the Southern followers, whose unit cost functions are respectively given by c_N, c_F and $c_S \equiv c(q_N, w_S)$. Because we focus on the case that $w_S \leq w_N$ and $q_N \leq q_F$, it is readily found that $c_S \leq c_N$ and $c_S \leq c_F$. Thus, the Southern followers are always the nearest rival. In consequence, in any industry j, the leader firm squeezes out its follower firms by charging the following limit price:

$$p_N = p_F = \lambda c_S$$
$$= \lambda \phi(\omega) w_N; \ \phi(\omega) \equiv c(1, \omega). \tag{9}$$

Using Eqs. (6) and (9) and the normalization $L_N E_N + L_S E_S \equiv 1$, the leader firm's output is given by $1/\lambda c_S$. Then, it is readily found that the instantaneous profit of firms staying in the North is:

$$\pi_N = (\lambda c_S - c_N) \frac{1}{\lambda c_S} = 1 - \frac{c(q_N, w_N)}{\lambda \phi(\omega) w_N}, \tag{10}$$

and that of firms engaging in FDI is:

$$\pi_F = (\lambda c_S - c_F) \frac{1}{\lambda c_S} = 1 - \frac{c(q_F, w_S)}{\lambda \phi(\omega) w_N}, \tag{11}$$

Finally, using Shepherd's lemma, the first condition of Eq. (7) with equality, and Eq. (8):

$$a_N^Z = c_1(1, 1)$$
$$a_N^L = c_2(1, 1)$$
$$a_F^Z = a_F^Z(\omega) \equiv c_1(1, \zeta(\omega))$$
$$a_F^L = a_F^Z(\omega) \equiv c_2(1, \zeta(\omega)); \zeta(\omega) \equiv \omega/[(1-\kappa)+\kappa\theta\omega] \leq \omega,$$

where $c_1(\cdot, \cdot)$ (resp. $c_2(\cdot, \cdot)$) is the partial derivative of $c(\cdot, \cdot)$ with respect to the first (resp. second) argument. For these derivations, the fact that the function $c_k(\cdot, \cdot)$ is homogenous of degree zero is also utilized.

2.2.2 R&D- and FDI activities
Now, we can turn to the R&D activities in the economy. It is assumed that if a Northern follower in an industry devotes $a_N^I \tilde{I}$ units of Northern labor for a time interval of length dt, it succeeds in updating the highest quality in this industry with

probability $\tilde{I}dt$, where $a_N^I > 0$ is assumed to take a fixed value. The firm that can succeed in inventing the highest quality can acquire the patent of the product with this quality, and becomes a leader firm in this industry. Let v_N denote the market value of the leader firm. Then the free entry conditions of the R&D activities are:

$$v_N \leq w_N a_N^I, \ \tilde{I} \geq 0, \ \tilde{I}(v_N - w_N a_N^I) = 0, \tag{12}$$

which means that $v_N = w_N a_N^I$ holds as long as $\tilde{I} > 0$. Let $I(j)$ denote the labor demand for R&D activities in industry j: i.e., $I(j)$ is the sum of $\tilde{I}$ within industry j. Then the aggregated labor demand for R&D over all industries is given by $I \equiv \int_0^1 I(j)dj$. It is assumed that the labor demand for R&D is symmetric across industries such that $I(j) = I$. This implies that in each industry, the probability for the current leader to be overtaken by a new entrant is simply given by Idt for a time interval of length dt.

Once a Northern firm succeeds in inventing the brand new highest quality, the firm determines its location pattern, that is, it determines whether it stays in the North or it engages in FDI. Let v_F denote the market value of the leader firm when it engages in FDI. Throughout the paper, we focus on the case in which the following relation holds:

$$v_{N,t} = v_{F,t} \ \forall t \geq 0. \tag{13}$$

Eq. (13) implies that in equilibrium, leader firms are indifferent between staying in the North and engaging in FDI.

Finally, we characterize the no-arbitrage condition. The no-arbitrage condition for the leader firm in the North is given by:[10]

$$\rho v_{N,t} = \pi_{N,t} + \dot{v}_{N,t} - I_t v_{N,t}. \tag{14}$$

In the above equation, the term $\dot{v}_{N,t}$ represents capital gains, while the term $-I_t v_{N,t}$ shows the expected capital loss that occurs with probability $I_t dt$. Because it is assumed that the leader firm can choose its location at each point in time without any cost, the no-arbitrage condition for the leader firm locating in the South is given in an analogous way:

$$\rho v_{F,t} = \pi_{F,t} + \dot{v}_{F,t} - I_t v_{F,t}. \tag{15}$$

From Eqs. (14) and (15), Eq. (13) means:

$$\pi_{N,t} = \pi_{F,t} \quad \forall t \geq 0. \tag{16}$$

2.3 Market-clearing condition

Let n denote the measure of the leader firm engaging in FDI. We have the labor market clearing conditions in the North and the South as follows:

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10) Recall that $r_t = \rho$ holds for all $t \geq 0$.

$$L_N = a_N^I I + Z_N + \frac{(1-n)a_N^L}{\lambda\phi(\omega)w_N}, \tag{17}$$

$$L_S = \theta Z_S + \frac{na_F^L(\omega)}{\lambda\phi(\omega)w_N}. \tag{18}$$

Next, the market-clearing condition for the intermediate input is characterized. The firms locating in the North can freely buy the intermediate input from the Northern market where it is cheaper than it is in the South. Then, their demand for the Northern-made input equals their total demand for the input, and this is given by $(1-n)a_N^z/(\lambda\phi(\omega)w_N)$. On the other hand, because of LCR by the Southern government, the firms engaging in FDI can buy only $(1-\kappa)\times100\%$ of their demand from the Northern market. Because their demand for the component is given by $na_F^z(\omega)/(\lambda\phi(\omega)w_N)$, the market-clearing condition for the intermediate input in the Northern market becomes:

$$Z_N = \frac{(1-n)a_N^z}{\lambda\phi(\omega)w_N} + \frac{n(1-\kappa)a_F^z(\omega)}{\lambda\phi(\omega)w_N}. \tag{19}$$

Accordingly, the Southern-made intermediate input is bought only by the firms engaging in FDI, which actually buy $\kappa\times100\%$ of their total demand from the Southern market. Therefore, the market-clearing condition for the Southern-made intermediate input is:

$$Z_S = \frac{n\kappa a_F^z(\omega)}{\lambda\phi(\omega)w_N}. \tag{20}$$

From Eqs. (17) and (19), the resource constraint in the North is given by:

$$L_N = a_N^I I + \frac{1}{\lambda\phi(\omega)w_N}[(1-n)\bar{\phi} + n(1-\kappa)a_F^z(\omega)]; \ \bar{\phi} \equiv a_N^z + a_N^L \equiv c(1,1), \tag{21}$$

where $\bar{\phi}$ represents the resulting amount of labor used by a leader firm in the North to produce one unit of final goods. The identity $\bar{\phi} \equiv c(1,1)$ is readily shown to hold, once we recall that $c(w_N, w_N) \equiv w_N a_N^z + w_N a_N^L$.

On the other hand, Eqs. (18) and (20) give the resource constraint in the South:

$$L_S = \frac{n}{\lambda\phi(\omega)w_N}[a_F^L(\omega) + \kappa\theta a_F^z(\omega)]. \tag{22}$$

3. Equilibrium

In this section, the equilibrium of the economy is characterized. From Eqs. (8), (10), (11) and the linear homogeneity of the unit cost function, Eq. (16) is rearranged as:

$$\bar{\phi} = c(1-\kappa+\kappa\theta\omega_t, \omega_t) \, \forall t \geq 0. \tag{23}$$

Because the function $c(\cdot, \cdot)$ is increasing in each argument, it is found that the right hand side of the above equation is increasing with respect to ω. Furthermore, because $\theta > 1$, it follows that:

$$\lim_{\omega \to 1/\theta} c(1-\kappa+\kappa\theta\omega_t, \omega) = c(1, 1/\theta) < \bar{\phi} \leq c(1-\kappa+\kappa\theta, 1$$

$$= \lim_{\omega \to 1} c(1-\kappa+\kappa\theta\omega, \omega) \,\forall\, \kappa \in [0, 1],$$

where the inequality $\bar{\phi} \leq c(1-\kappa+\kappa\theta, 1)$ holds with equality if and only if $\kappa = 0$. Thus, from the intermediate value theorem, there uniquely exists $\omega^*(\kappa) \in (1/\theta, 1]$ such that it solves Eq. (23) as follows:

$$\omega_t = \omega^*(\kappa) \,\forall\, t \geq 0, \tag{24}$$

where $\omega_t = 1$ if $\kappa = 0$. Because the unit cost function is linearly homogenous, its partial derivatives are homogenous of degree zero. Therefore, once ω_t is determined as $\omega^*(\kappa)$, $a_F^Z(\omega)$ and $a_F^L(\omega)$ are also given as functions of κ alone as follows:

$$a_F^{Z*}(\kappa) \equiv a_F^Z(w^*(\kappa)) \equiv c_1(1, \zeta^*(\kappa)) \leq a_N^Z,$$

$$a_F^{L*}(\kappa) \equiv a_F^L(w^*(\kappa)) \equiv c_2(1, \zeta^*(\kappa)) \geq a_N^L; \; \zeta^*(\kappa) \equiv \zeta(\omega^*(\kappa)),$$

where $a_F^{Z*}(\kappa) \leq a_N^Z$ and $a_F^{L*}(\kappa) \geq a_N^L$ come from $\zeta^*(\kappa) \leq \omega^*(\kappa)$ and the properties of the unit cost function: $c_{12}(\cdot, \cdot) > 0$ and $c_{22}(\cdot, \cdot) < 0$.

From Eqs. (9) and (24), the charged price by leader firms is found to be:

$$p_N = p_F = \lambda\phi^*(\kappa)w_N; \; \phi^*(\kappa) \equiv \phi(\omega^*(\kappa)) \equiv c(1, \omega^*(\kappa)). \tag{25}$$

Note that from the definitions of $\bar{\phi}$ and $\phi^*(\kappa)$, $\phi^*(\kappa) \leq \bar{\phi}$, the equality of which holds true when $\kappa = 0$: i.e., $\omega^*(\kappa) = 1$. Substituting Eq. (25) and the fact that $q_N = w_N$ into Eq. (10), the instantaneous profit of the leader firms is found to be:

$$\pi_N = \pi_F = 1 - \frac{\bar{\phi}}{\lambda\phi^*(\kappa)}. \tag{26}$$

Hereafter, it is assumed that λ is sufficiently large such that $\lambda > \bar{\phi}/\phi^*(1) > 1$.

Now we are in a position to derive the equilibrium path of the economy. Applying the above results into Eq. (21):

$$L_N = a_N^I I + \frac{(1-n)\bar{\phi}}{\lambda\phi^*(\kappa)w_N} + \frac{n(1-\kappa)a_F^{Z*}(\kappa)}{\lambda\phi^*(\kappa)w_N}. \tag{27}$$

On the other hand, from Eq. (22):

$$L_S = \frac{n}{\lambda\phi^*(\kappa)w_N} \frac{\bar{\phi}-(1-\kappa)a_F^{Z*}(\kappa)}{\omega^*(\kappa)}, \tag{28}$$

where the following identity is utilized: $\bar{\phi} \equiv (1-\kappa+\kappa\theta\omega^*(\kappa))a_F^{Z*}(\kappa)+\omega^*(\kappa)a_F^{L*}(\kappa)$, which comes from the fact that $c(q_N, w_N) = c(q_F, w_S)$ from Eq. (16) (or Eq. (23)) and the definition of the unit cost function.

We focus on the case in which the free entry/exit condition for R&D is always binding: i.e., the first condition of Eq. (12) holds with equality for all $t \geq 0$: $v_N = w_N a_N^I$ for all $t \geq 0$. Then, from Eqs. (14), (26), (27) and (28), the following linear ordinary differential equation holds:

$$\hat{v}_{N,t} = \left(\frac{\rho a_N^I + L_N + \omega^*(\kappa)L_S}{a_N^I}\right)v_{N,t} - 1.$$

The above equation constitutes an autonomous dynamic system of this economy. This equation implies:

$$\dot{v}_{N,t} \gtreqless 0 \Leftrightarrow v_{N,t} \gtreqless v_N^*(\kappa) \equiv \frac{a_N^I}{\rho a_N^I + L_N + \omega^*(\kappa) L_S}.$$

Because $v_{N,t}$ is a forward-looking variable, the above result says that the economy has no transitional dynamics and $v_{N,t} = v_N^*(\kappa)$ for all $t \geq 0$.

Our final task in this section is to derive the other major endogenous variables and check some consistency conditions. Substituting the result that $v_{N,t} = v_N^*(\kappa)$ into Eqs. (27) and (28) respectively yields:

$$I_t = I^*(\kappa) \equiv \frac{[1 - \bar{\phi}/(\lambda\phi^*(\kappa))](L_N + \omega^*(\kappa) L_S)}{a_N^I} - \rho\bar{\phi}/(\lambda\phi^*(\kappa)),$$

and

$$n_t = n^*(\kappa) \equiv \frac{\omega^*(\kappa)}{\bar{\phi} - (1-\kappa) a_F^{Z*}(\kappa)} \frac{\lambda\phi^*(\kappa) L_S}{\rho a_N^I + L_N + \omega^*(\kappa) L_S}.$$

Therefore, we have to check $I^*(\kappa) > 0$ and $n^*(\kappa) \in (0, 1)$. Note that from Eq. (19), $Z_N > 0$ is automatically satisfied if $n^*(\kappa) \in (0, 1)$.

At first, differentiating $I^*(\kappa)$ yields:

$$\frac{dI^*(\kappa)}{d\kappa} = \frac{\bar{\phi}[(L_N + \omega^*(\kappa)L_S)/a_N^I + \rho]}{\lambda(\phi^*(\kappa))^2} \frac{d\phi^*(\kappa)}{d\kappa} + \frac{[1 - \bar{\phi}/(\lambda\phi^*(\kappa))]L_S}{a_N^I} \frac{d\omega^*(\kappa)}{d\kappa} < 0, \tag{29}$$

the sign of which holds true from the following facts:

$$d\omega^*(\kappa)/d\kappa = -\frac{(\theta\omega^*(\kappa) - 1) a_S^{Z*}(\kappa)}{\kappa\theta a_F^{Z*}(\kappa) + a_F^{L*}(\kappa)} < 0,$$

$$-d\phi^*(\kappa)/d\kappa = c_2(1, \omega^*(\kappa))(d\omega^*(\kappa)/d\kappa) < 0.$$

Thus, $I^*(\kappa)$ is a decreasing function of κ, meaning that $I^*(1) > 0$ must be satisfied in equilibrium. This condition is arranged as $L_S > \omega^*(1)^{-1}[\bar{\phi}\rho a_N^I/(\lambda\phi^*(1) - \bar{\phi}) - L_N]$.

On the other hand, it is readily found that $n^*(\kappa) > 0$ for all $\kappa \in [0, 1]$. Then, in order to understand the condition $n^*(\kappa) \in (0, 1)$, we have to examine when $n^*(\kappa) < 1$ only. Logarithmically differentiating $n^*(\kappa)$, we have:

$$\frac{dn^*(\kappa)/n^*(\kappa)}{d\kappa/\kappa} = -\frac{\kappa a_F^{Z*}(\kappa)}{\bar{\phi} - (1-\kappa) a_F^{Z*}(\kappa)} \left(1 - (1-\kappa)\frac{da_F^{Z*}(\kappa)/d\kappa}{a_F^{Z*}(\kappa)}\right)$$

$$+ \frac{\kappa(d\phi^*(\kappa)/d\kappa)}{\phi^*(\kappa)} + \left(1 - \frac{\omega^*(\kappa)L_S}{\rho a_N^I + L_N + \omega^*(\kappa)L_S}\right)\frac{\kappa(d\omega^*(\kappa)/d\kappa)}{\omega^*(\kappa)} < 0, \tag{30}$$

the sign of which is shown to be true from $d\omega^*(\kappa)/d\kappa < 0$, $d\phi^*(\kappa)/d\kappa < 0$ and

$$da_F^{Z*}(\kappa)/d\kappa = c_{12}(1, \zeta^*(\kappa))(d\zeta^*(\kappa)/d\kappa) < 0.$$

Then, in equilibrium, $n^*(0) < 1$ must be met. This condition is rewritten as

$L_S \lessdot a_N^L(L_N + \rho a_N^I)/(\lambda\bar\phi - a_N^L)$.[11] If L_N is sufficiently large and ρ is sufficiently small, the set of L_S is not empty where both $n^*(0) < 1$ and $I^*(1) > 0$ are satisfied. Then, we can state the following proposition:

Proposition 1. *Suppose that $L_S > \omega^*(1)^{-1}[\bar\phi\rho a_N^I/(\lambda\phi^*(1) - \bar\phi) - L_N]$ and $L_S < a_N^L (L_N + \rho a_N^I)/(\lambda\bar\phi - a_N^L)$ are satisfied. Then, there uniquely exists an equilibrium of the economy with endogenous innovation, FDI, LCR and without transitional dynamics.*

4. Effects of LCR

4.1 Effects on innovation, FDI and intermediate input sector

From the analyses in the previous section, we can immediately arrive at the following lemma:

Lemma 1. *The reinforcement (relaxation) of LCR by the Southern government reduces (promotes) FDI and innovation in the North.*

Proof. This lemma is shown to be true from Eqs. (29) and (30). ∎

The mechanism generating this lemma is as follows. In this model, a reducing LCR (a decrease in κ) by the Southern government has four main effects on the resource constraint in the North: the compulsory-resource allocating effect, the components-intensification effect, the price effect and the FDI-inducing effect. To grasp how these effects affect innovation in the North, we differentiate Eqs. (27), (14) with $\dot v_N = 0$, and (28) to obtain:

$$dI^* = \frac{1}{\lambda\phi^* v_N^*}\left\{ n^*\left(a_F^{Z*} - (1-\kappa)\frac{da_F^{Z*}(\kappa)}{d\kappa}\right)d\kappa \right.$$
$$\left. + [(1-n^*)\bar\phi + n^*(1-\kappa)a_F^{Z*}]\left(\frac{\phi_\kappa^*(\kappa)}{\phi^*(\kappa)}d\kappa + \frac{dv_N^*}{v_N^*}\right) + [\bar\phi - (1-\kappa)a_F^{Z*}]dn^* \right\},$$
$$\tag{31}$$

$$dv_N^* = \frac{1}{(\rho + I^*)^2}\left[\frac{\bar\phi(\rho + I^*)}{\lambda\phi^{*2}}\phi_\kappa^*(\kappa)d\kappa - \left(1 - \frac{\bar\phi}{\lambda\phi^*}\right)dI^*\right] \tag{32}$$

$$dn^* = n^*\left[\frac{\omega_\kappa^*(\kappa)}{\omega^*}d\kappa - \frac{1}{\bar\phi - (1-\kappa)a_F^{Z*}}\left(a_F^{Z*} - (1-\kappa)\frac{da_F^{Z*}(\kappa)}{d\kappa}\right)d\kappa \right.$$
$$\left. + \left(\frac{\phi_\kappa^*(\kappa)}{\phi^*(\kappa)}d\kappa + \frac{dv_N^*}{v_N^*}\right)\right]. \tag{33}$$

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11) To prove this, we can utilize the facts that $\omega^*(0) = 1$ (from Eq. 23), $\phi^*(0) = c(1,1) = \bar\phi$ and $\zeta^*(0) = 1$, the last of which means $a_F^{Z*}(0) = a_N^Z$, $a_F^{L*}(0) = a_N^L$.

These expressions clearly show how each of the aforementioned four effects affect innovation through the resource constraint in the North. In Eq. (31), the first term represents the sum of the compulsory-resource allocating effect and the components-intensification effect, where the former is captured by $a_F^{Z*}(\kappa)$ and the latter by $(1-\kappa)(da_F^{Z*}(\kappa)/d\kappa)$. These two effects are found to jointly reduce innovation if LCR is relaxed. This is because as LCR is relaxed, the firms engaging in FDI purchase more intermediate input from the North (the compulsory-resource allocating effect), and each firm uses the intermediate input more intensively (the components-intensification effect).[12]

On the other hand, the second term captures the price effect. From the endogenous location choice of leader firms, relaxing LCR has upward pressure on the wage rate in the South $(d\omega^*(\kappa)/d\kappa < 0)$, because Eq. (23) must be met. This makes the marginal cost of follower firms increase, which is transmitted to a leader firm's charging price through its limit pricing strategy. Because the output of final goods is given by the inverse of the price, reducing LCR can positively affect innovation activities in the North. This effect is captured by the term $\phi_\kappa^*(\kappa) < 0$. From Eq. (32), however, the price effect also has a negative impact on innovation through a kind of general equilibrium effect. In this model, innovation causes an increase in the capital loss, because of being overtaken by the new leader firms. This implies that the wage rate in the North declines through the free entry/exit condition for innovation activities. This may make the charged price lower, which in turn may reduce innovation. This effect is captured by dv_N^*, which is affected by dI^*. Thus, the price effect on innovation is ambiguous.

Finally, the third term represents the FDI-inducing effect. By a close look at Eq. (33), it is found that this effect emerges from the resource constraint in the South and the aforementioned three effects. The first term of Eq. (33) is the direct effect of reducing LCR on FDI: a decrease in κ makes it more profitable for firms to engage in FDI. The second term is the sum of the compulsory-resource allocating effect and the components-intensification effect. Note that this effect has an impact on the resource constraint in the South opposite to that in the North. As LCR is relaxed, the firms engaging in FDI purchase the intermediate input from the North, meaning that this makes the labor used for the production of final goods in the South more abundant. This promotes FDI by the Northern firms. The third effect is the price effect.

Obviously, substituting Eqs. (32) and (33) into Eq. (31) yields Eq. (29), and substituting the result back into (33) yields Eq. (30). Thus, we can now conclude that the result obtained in Eq. (29) shows that the FDI-inducing effect outweighs the other effects, which possibly have opposite effects on innovation.

The above discussions explain one reason why the Northern government wants

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12)   To see why, recall $a_F^{Z*}(\kappa)/d\kappa < 0$.

the Southern one to liberalize foreign investment. On the other hand, the following lemma shows that from the Southern government's point of view, maintaining LCR plays a role in protecting the domestic intermediate input industry.

Lemma 2. *Suppose that* $\kappa = 0$ *: i.e., the Southern government abolishes LCR and the intermediate input is freely traded between the North and the South. Then, the intermediate input sector in the South shuts down and hence all final goods firms purchase the input from the Northern intermediate input sector.*

Proof. Substituting the results obtained in the preceding section into Eq. (20):

$$Z_S = Z_S^*(\kappa) \equiv \frac{\kappa a_F^{Z*}(\kappa)}{\bar{\phi} - (1-\kappa)a_F^{Z*}(\kappa)} \omega^*(\kappa)L_S.$$

Substituting $\omega^*(0) = 1$, $a_F^{Z*}(0) = a_N^{Z*}$ and $\phi^*(0) = \bar{\phi}$ into this, it is easily verified that $Z_S^*(\kappa) = 0$ if $\kappa = 0$. Then, in order to prove this lemma, it is sufficient to show that $Z_S = 0$ is consistent with the intermediate good firms' profit maximization: i.e., we have only to check that the first condition of Eq. (7) holds with strict inequality. If the input is freely traded, $q_N = q_S = q$ must be met. On the other hand, $\omega^*(\kappa) = 1$ if $\kappa = 0$, which implies $w_S = w_N$. Then, $q = w_N < \theta w_N$ holds, which means that the first condition of Eq. (7) holds with strict inequality and hence the intermediate input sector in the South could earn a negative profit if it operates. ∎

Thus, Lemma 1 and Lemma 2 seemingly suggest that there is a conflict between the Northern and Southern governments concerning whether or not to relax and/or abolish LCR. The Northern government, in order to promote domestic innovation activities, wants to continue the process of investment liberalization, whereas the Southern government wants to protect domestic industry that otherwise will decline as a direct result of the abolishment of LCR. However, the results obtained here do not really help us to judge whether strengthening LCR is beneficial or harmful for the South, because we have not presented any welfare implications yet. The next subsection therefore investigates the welfare implication of LCR.

4.2 Welfare effects

Because the economy has no transitional dynamics, the lifetime utility (1) is now rewritten as:

$$U_i = \frac{1}{\rho}[\ln E_{i,0} - \ln(\lambda \phi^*(\kappa) w_{N,0})] + \int_0^\infty \left(\ln \lambda \int_0^1 \bar{m}_t(j)dj\right)\exp(-\rho t)dt, \quad (34)$$

where the first term is the utility from the quantity of consumption, while the second term captures utility from the quality of consumption. The first term, in turn, depends positively on the household's expenditure (or income), but negatively on the price. Thus, the welfare effect of reducing LCR can be decomposed into the

following three effects: the growth effect, the income effect and the price effect. From Eqs. (3) and (4), the expenditure is given as the following well known form:

$$E_{i,0} = \rho A_{i,0} + w_{i,0}.$$

Because the asset market equilibrium implies $L_N A_{N,0} + L_S A_{S,0} = v^*(\kappa)$, and country i's initial share of asset holdings is given as the initial condition, we can set $\eta_0 \in (0, 1) \times 100\%$ of equities to be held by the Northern households without any loss of generality: i.e., $L_N A_{N,0} = \eta_0 v^*(\kappa)$. Using this, the expenditure of the representative consumer in the North and the South, E_N and E_S, is respectively:

$$E_{N,0} = (\rho a_N^l \eta_0 / L_N + 1) v^*(\kappa) / a_N^l,$$
$$E_{S,0} = [\rho a_N^l (1 - \eta_0) / L_S + \omega^*(\kappa)] v^*(\kappa) / a_N^l.$$

On the other hand, $\int_0^1 \tilde{m}_t(j) dj$ in the second term of Eq. (34) is the sum of the number of events (innovation) that have occurred up to time t in all industries. Because the measure of industry is unity, this can be viewed also as the sample mean. From the law of large numbers, this is equal to an expected amount of innovation that will occur up to time t in an industry. In other words:

$$\int_0^1 \tilde{m}_t(j) dj = \int_0^t I^*(\kappa) dt = I^*(\kappa) t.$$

Substituting the above results into Eq. (34) yields welfare in the North and South as follows:

$$U_N = \frac{1}{\rho} \left\{ \ln [\rho a_N^l \eta_0 / L_N + 1] - \ln \phi^*(\kappa) - \ln \lambda + \frac{\ln \lambda}{\rho} I^*(\kappa) \right\},$$

$$U_S = \frac{1}{\rho} \left\{ \ln [\rho a_N^l (1 - \eta_0) / L_S + \omega^*(\kappa)] - \ln \phi^*(\kappa) - \ln \lambda + \frac{\ln \lambda}{\rho} I^*(\kappa) \right\}.$$

Differentiating U_N and U_S with respect to κ yields:

$$\frac{dU_N}{d\kappa} = \frac{1}{\rho} \left(\frac{\ln \lambda}{\rho} \frac{dI^*(\kappa)}{d\kappa} - \frac{1}{\phi^*(\kappa)} \frac{d\phi^*(\kappa)}{d\kappa} \right), \tag{35}$$

$$\frac{dU_S}{d\kappa} = \frac{dU_N}{d\kappa} + \frac{L_S/\rho}{\rho(1-\eta_0)a_N^l + \omega^*(\kappa)L_S} \frac{d\omega^*(\kappa)}{d\kappa}. \tag{36}$$

Because $d\omega^*(\kappa)/d\kappa < 0$, Eqs. (35) and (36) jointly say that $dU_S/d\kappa < 0$ if $dU_N/d\kappa < 0$, which is summarized as:

Lemma 3. *If the welfare of Northern households improves by relaxation of LCR, then the welfare of Southern households necessarily improves.*

Then, based on this result, let us hereafter consider the possibility that both countries arrive at an agreement to relax LCR (decrease κ): i.e., relaxing LCR is Pareto improving. From Lemma 3, $dU_N/d\kappa < 0$ is the sufficient condition for relaxing LCR to be so.

Taking a close look at Eq. (35), it is found that the income effect and the price effect combine to be negative for the Northern representative consumer. Thus, we

have to examine when the growth effect dominates such a negative effect. Substituting Eq. (29) and $d\phi^*(\kappa)/d\kappa$, we have:

$$\frac{dU_N}{d\kappa} = \frac{1}{\rho}\left[\alpha\Gamma(\kappa) + \frac{\ln\lambda}{\rho a_N^I}\left(1 - \frac{\bar{\phi}}{\lambda\phi^*(\kappa)}\right)\omega^*(\kappa)L_S\right]\frac{d\omega^*(\kappa)/d\kappa}{\omega^*(\kappa)}; \qquad (37)$$

$$\Gamma(\kappa) \equiv \frac{\ln\lambda}{\lambda}\frac{\bar{\phi}}{\phi^*(\kappa)}\left(1 + \frac{L_N + \omega^*(\kappa)L_S}{\rho a_N^I}\right) - 1,$$

where $\alpha \equiv \omega c_2(1, \omega)/c(1, \omega) \in (0, 1)$ equals the labor share. Hereafter, α is assumed to be constant.[13] From Eq. (37), it is found that $dU_N/d\kappa < 0$ if $\Gamma(\kappa) > 0$. Furthermore, if the value of α is sufficiently large, $\Gamma(\kappa)$ is an increasing function of κ. Thus, the sufficient condition for $dU_N/d\kappa < 0$ to hold is given by $\Gamma(0) > 0$, which is rewritten as:

$$\ln\lambda\left(1 + \frac{L_N + L_S}{\rho a_N^I}\right) > \lambda.$$

Now, we can state the following proposition:

Proposition 2. *Suppose that the two assumptions in Proposition 1 are satisfied, and that α is sufficiently large. Then, a relaxation of LCR is Pareto improving if $\Gamma(0) > 0$.*

5. Concluding remarks

Many developing countries have been obliged to eliminate a range of restrictions on foreign investment, and they seem to be afraid that to do so will damage their domestic industries. Whether or not to abolish LCR is a typical example of such a problem. This paper constructed a North-South quality-ladder model where FDI is endogenously determined and is affected by such an investment measure, and gives a hypothetical answer to this problem. This paper showed that once the endogenous location choice and innovation are explicitly incorporated into the general equilibrium model, which has been overlooked in the existing literature on LCR, reducing LCR can raise welfare not only in the North but also in the South. Thus, this result can give a rationale for recommending that developing countries liberalize foreign investment.

To analytically examine the problem of LCR in a dynamic general equilibrium framework, this paper makes some restrictive assumptions. First, the nonexistence of any fixed costs for firms to engage in FDI rules out transitional dynamics. Although this facilitates a simple analytical examination of the welfare effects of LCR, fixed costs are likely to be present in reality. Second, in order to focus on

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13) Thus, we assume the unit cost function $c(q, w)$ to be $\bar{\phi}q^{1-\alpha}w^\alpha$.

firms' location choice, this paper assumes away any trade barriers such as transportation costs. Thus, this paper should be seen as a benchmark case against future policy-oriented papers.

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