The Impact of a Natural Disaster on Foreign Direct Investment and Vertical Linkages

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Abstract

How do multinational enterprises (MNEs) affect the host country through their vertical industrial linkages when large natural disasters occur? To answer this question, we develop a simple theoretical framework and show that, as trade costs decline, the host country is first dominated by MNEs and then later by local firms. Thus, when natural disasters seriously damage capital, the industrial configurations in the host country switch from domination by MNEs to domination by local firms. The replacement of MNEs with local firms can raise the welfare of the host country.

JEL codes: F12; F23; Q54.

Keywords: Multinationals enterprises (MNEs); Natural disasters; Industrial linkages; Multiple equilibria.

1 Introduction

Foreign direct investment (FDI) has drastically increased in recent decades. It is well known that multinational enterprises (MNEs) can either stimulate or hamper the development of their host countries. The governments of host countries, particularly in developing countries and emerging markets, have sought to attract MNEs from developed countries by offering

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economic incentives, such as subsidies and tax deductions. MNEs can contribute to the local economies by boosting average productivity and employment. On the other hand, severe competition driven by MNEs can crowd out local firms and deter the entry of potential local entrepreneurs, which would hamper economic growth in the local economies. There is a long tradition of FDI studies investigating the pros- and cons of the impact of MNEs on host countries. For example, Markusen and Venables (1999) find that MNEs can help local firms to increase their production through industrial vertical linkages and stimulate the development of the whole host economy.

Less well known is the nexus between MNEs and major negative shocks. Developing countries often face various large shocks and risks, making their economies rather volatile and fragile (Koren and Tenreyro, 2007; Bloom, 2014). In particular, in recent years, many developing countries have experienced severe damage as a result of the frequent occurrence of natural disasters (Bordo et al., 2001; ADB, 2013). As MNEs play crucial roles in shaping the development of their host countries, the survival of MNEs in the face of negative shocks is essential to the host countries. Furthermore, the transmission of the negative shocks through the MNEs has a nonnegligible impact on their source countries.

Of the many types of large negative shocks, our main interest is in the consequence of natural disasters. Thailand's large-scale of flood in 2011 is a notable example of the destructive effects of a natural disaster on manufacturing and MNEs. According to Haraguchi and Lall (2015), as a result of this flood, 17,578 square kilometers of farmlands were inundated, causing estimated economic damage of 46.5 billion USD across all sectors. Manufacturing alone suffered 32 billion USD of damage. Seven industrial parks and 904 factories were inundated, 55% of which were MNEs owned by Japanese firms. The business operations of many factories completely ceased for one to two months, Subsequently, only 40% of the factories in the industrial parks recovered to their preflood production levels, 17.5% could not resume operations, and 15% decided to shut down their factories (as of June 2012). More generally, the Bank of Thailand concluded that, unless appropriate measures were taken by the government, the flood would relocate more MNEs to other Asian countries in the long term (BOT, 2012).[1]

There are many ways in which MNEs impact on their host countries, including through technology spillovers and labor market. Our paper focuses on the vertical linkages between

[1]The relocation of MNEs as a result of natural disasters has occurred even in developed countries. METI (2011) documents some cases of relocation or exit of foreign owned firms and banks in Tokyo after the nuclear accident in Fukushima, caused by the Great East Japan earthquake in 2011.

upstream and downstream sectors and investigates how MNEs shape and change industrial configurations in the face of large negative shocks, such as natural disasters. To address this issue, our model takes into account two major characteristics of MNEs: (i) industrial vertical linkages; and (ii) footlooseness. The first characteristic indicates that MNEs change supply and demand through their input-output linkages in the host country. Suppose that MNEs are located in the downstream sector of the host country. The local firms in the upstream sector would benefit enormously from downstream MNEs because of their demand for intermediate inputs. Conversely, a larger supply of local upstream firms would assist the downstream MNEs because of lower prices for intermediate inputs. The second characteristic, footlooseness, arises because, although MNEs have a large amount of capital, they are sensitive to negative shocks in their location and, thus, the capital is footloose across countries. That is, MNEs are more likely to enter and exit a host country than are local firms (Görg and Strobl, 2003; Bernard and Jensen, 2007).

Negative shocks result in serious damage to capital. Large-scale natural disasters often cause bank liquidity shocks and destroy large quantities of physical capital (Cole et al., 2015; Hosono et al., 2016). After a negative shock occurs, MNEs may sustain their physical capital with the aid of their parent firms in the source countries. The parent firms can immediately provide capital to their foreign affiliates to enable a quick recovery, thereby also contributing to the recovery of the host country. On the other hand, the footlooseness of MNEs may cause the opposite situation to occur. The negative shocks could destroy local upstream suppliers and, thus, MNEs might find it profitable to leave the host country. Our paper provides a simple model to explore how MNEs would influence the local economy through vertical linkages and how negative shocks would change the equilibrium path.

1.1 Related literature

Many studies have investigated the impact of MNEs on industrial development. One of the main issues examined has been whether MNEs help the development of local suppliers and customers through input-output linkages.[2] Some studies find that the presence of MNEs in the downstream sector has a positive impact on local firms in the upstream sector (e.g., Javorcik, 2004). More generally, using Irish micro-level data, Görg and Strobl (2002a,b) empirically show that MNEs promote the entry of local firms. Aitken et al. (1997) suggest

[2] Chang and Xu (2008) study competition among foreign and local firms in China.

that MNEs have a positive impact on the probability of local firms exporting.[3] Turning to theoretical works, some studies on MNEs examine the vertical linkages of upstream and downstream sectors (Rodriguez-Clare, 1996; Markusen and Venables, 1999; Carluccio and Fally, 2013), and find that the locally produced intermediate inputs crucially influence multinational production and entry- and exit in the host country. The closest study to our present work, Markusen and Venables (1999), suggests that MNEs are complementary to local firms, leading to the promotion of local firms through vertical linkages of the downstream and upstream sectors.[4] They show that, in the early stage of development, the number of MNEs in the host country increases, but that this trend reverses and they are crowded out in the later stage. Markusen and Venables conclude that MNEs work as a catalyst in the development of the host country.

Little attention has been paid in the FDI literature to the impact on MNEs of large-scale negative shocks in the host country. However a growing literature outside this field has examined the macroeconomic impact of natural disasters (see Cavallo and Noy, 2011 for a survey). Although many studies report negative impacts on economic growth (e.g., Hallegatte and Dumas, 2009; Noy, 2009; Strobl, 2012), a few find positive impacts (Albala-Bertrand, 1993; Skidmore and Toya, 2002; Husby et al., 2014). Disasters could provide an opportunity to update the capital stock and promote capital growth, through a process known as creative destruction (Leiter et al., 2009). One implication is that natural disasters could change the equilibrium path of economic growth in the damaged countries.

More recent studies using micro-level data find that natural disasters destroy enormous amounts of physical capital, reducing productivity and the survival rates of firms (Cole et al., 2015). Natural disasters often involve bank liquidity shocks, which discourage capital investment by firms and prevent recovery from the shocks. Examining the case of the volcanic eruptions in Ecuador, Berg and Schrader (2012) find that this natural disaster made it difficult for small firms to access credit markets, thereby reducing their investment. As Hosono et al. (2016) show, bank liquidity shocks after the Kobe earthquake in Japan negatively affected client firms' investment.[5] Although these studies do not particularly focus on MNEs, we can

[3]See also Kugler (2006); Blalock and Gertler (2008).

[4]Rivera-Batiz and Rivera-Batiz (1990) also study the effect of MNE entry on the upstream and downstream sectors.

[5]MNEs could contribute to mitigating damage caused by severe shocks through their formation of international production network. Some empirical studies find that, during natural disasters and financial crisis, international production networks (Asian fragmentation) promote the sustainability and resilience of production, particularly in machinery sectors (Obashi, 2010; Ando and Kimura, 2012; Okubo et al., 2014).

infer that a large capital shock could drastically change the relationship between MNEs and local firms through their industrial linkages. Our theoretical investigation uncovers answers to this issue.

Only recently have a few empirical studies focused on the nexus between natural disasters and MNEs. Escaleras and Register (2011); and Anuchitworawong and Thampanishvong (2015) find that major natural disasters reduce FDI inflows, while Oh and Oetzel (2011) find that there is no significant impact on the number of MNEs.[6] As these studies involve macro-level analyses, unknown still is the precise mechanism through which capital damage, induced by negative shocks, change the equilibrium configuration between MNEs and local firms in downstream and upstream sectors.

To our knowledge, there is virtually no theoretical studies on MNEs and negative shocks. The key exceptions are Aizenman (2003); and Aizenman and Marion (2004), who model how supply and demand shocks affect FDI and suggest that greater volatilities of these shocks tend to reduce FDI. Their predictions are empirically supported by some subsequent studies (e.g., Russ, 2007). However, the main focus of these studies is risk under uncertainty. By contrast, our model highlights the actual damage, rather than risks, given the context of such natural disasters recently causing large downturns and enormous capital damage and losses in the developing world.

Our paper yields several results. First, there is the possibility of multiple equilibria, the one in which MNEs are dominant and another in which local firms are dominant, when trade costs are at intermediate level. Second, a large negative capital shock caused by natural disasters results in a switch from the equilibrium in which MNEs are dominant to the alternative equilibrium, dominated by local firms. Even if the natural disaster is a temporary shock, the equilibrium switch is irreversible. Third, social welfare could increase in the host country as a result of the natural disaster, through the process known as creative destruction, as the natural disaster crowds out MNEs but fosters local firms.

The reminder of the paper proceeds as follows. The next section describes the basic ingredients of the model. Section 3 explores the equilibrium capital allocation characterized by trade costs. Section 4 examines the impact of the negative shock on capital in the host

[6] Escaleras and Register (2011) use cross-country data, whereas Anuchitworawong and Thampanishvong (2015) focus on Thailand. Hayakawa et al. (2015) report that the Thailand flood in 2011 led Japanese foreign affiliates to change their sourcing patterns. Using data from foreign affiliates of 71 European MNEs, Oh and Oetzel (2011) find that major natural disasters have no significant impact on the number of subsidiaries of MNEs, while terrorist attacks and technological disasters have negative impacts.

country. Its effect on welfare is derived in Section 5. Section 6 considers three extensions, involving small negative shocks, MNE subsidies, and capital allocation by forward-looking decisions. The final section concludes the paper.

2 The model

We consider one country (the host) and the rest of the world (the foreign). We focus on markets in the host country. The basic model framework is summarized in Fig. 1. There are a monopolistically competitive industrial sector and a competitive nonindustrial sector in the host country. The industrial sector has two subsectors, an intermediate goods/upstream sector and a final goods/downstream sectors, each of which produces differentiated products. The upstream sector has local producers called *U-firms*, whereas the downstream sector has local producers called *D-firms*, and producers coming from the foreign country, called *MNEs*. The two subsectors are tightly linked through vertical linkages, and the U-firms supply their goods to the D-firms as well as to the MNEs. For simplicity, there are no exports and imports of the intermediate goods. In addition to MNEs and local D-firms in the host country, final goods producers located in the foreign country, called *F-firms*, export their products to the host country. Thus, final goods are supplied to consumers by three different types of firms: D-firms, MNEs, and F-firms. The international shipment of final goods from F-firms incurs trade costs, whereas the nonindustrial good is costlessly traded.

The primary production factors are labor and capital. The host county and the foreign country are endowed with K and K_f units of capital, respectively. Following the economic geography model developed by Martin and Rogers (1995) (known as the footloose capital model), firms need local workers as the variable input and use one unit of capital as the fixed input. Thus, there is a one-to-one correspondence between the number of four-type firms and the amount of capital allocated to each type. The capital in the host country moves between U-firms and D-firms, while the capital in the foreign country is allocated between MNEs and F-firms.

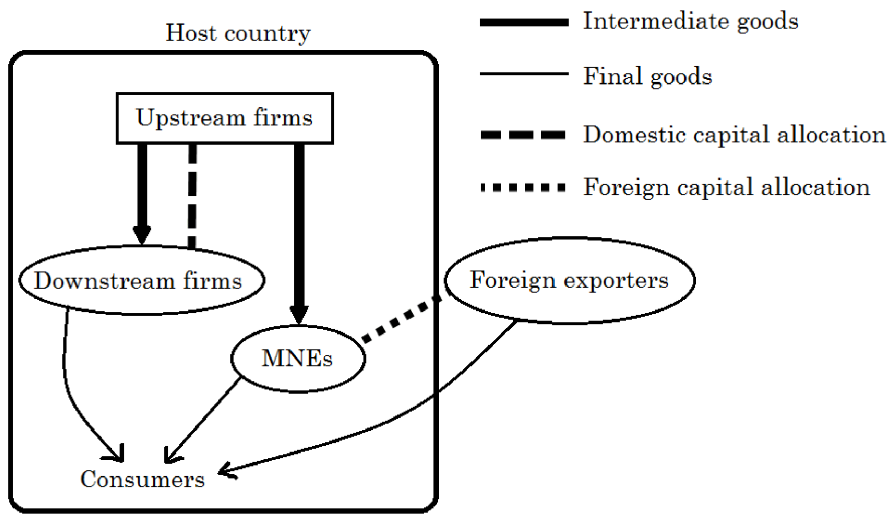

Fig. 1. Model structure.

Consumers. Each consumer in the host country has the following utility function:

$$u = \alpha \log Q + q_0, \tag{1}$$

$$\text{where} \quad Q = \left[\sum_i \int_{\omega \in \Omega_i} q_i(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}}, \quad i \in \{d, m, f\},$$

Q is the composite of the differentiated final goods. $q_i(\omega)$ is the demand for an individual variety of ω produced by the type-$i \in \{d, m, f\}$ firm, where the subscripts of d, m, and f denote D-firms, MNEs and F-firms, respectively. q_0 is the (individual) demand for nonindustrial goods, α is the expenditure on final goods, and $\sigma > 1$ measures the elasticity of substitution between them. We will suppress the variety index of ω in what follows.

The demand for a variety of final goods is given by

$$q_i = \left(\frac{p_i}{P}\right)^{-\sigma} \frac{E}{P}, \quad i \in \{d, m, f\},$$

$$\text{where} \quad P = \left(\sum_i N_i p_i^{1-\sigma} \right)^{\frac{1}{1-\sigma}}.$$

p_i is the price of the type-i firm and P is the price index. N_i denotes the number of the type-i firm, and E denotes total expenditure on final goods. Let L be the population in the host country. The quasilinear preference implies that $E = \alpha L$.

Nonindustrial sector. The nonindustrial sector is perfectly competitive and the good is internationally traded without trade costs at the constant world price p_0. Let w be the wage rate in the host country. The constant returns to scale technology with the unit labor requirement of $a_0 = 1$ implies that $p_0 = wa_0 = w$. Workers cannot move between countries but freely move between the industrial sector and the nonindustrial sector so that the wage rate becomes identical between the two sectors.

Local upstream firms (U-firms). The cost function of the local upstream firm (the U-firm) is given by

$$C_u(q_u) = waq_u + \pi_u,$$
$$\text{where} \quad q_u = \left(\frac{p_u}{P_u}\right)^{-\sigma} I.$$

I is the total demand for the intermediate input, which will be discussed shortly. Each U-firm needs aq_u units of labor and one unit of *domestic* capital K. π_u is the rental rate of domestic capital for U-firms. The optimal pricing by the U-firm implies that $p_u = \sigma wa/(\sigma - 1)$, where $\sigma > 1$ measures the degree of product differentiation in the upstream sector, which is assumed to be identical to that in the downstream sector, for simplicity. As the labor coefficient is chosen so that $a = (\sigma - 1)/\sigma$ holds, we have $p_u = w$. Hence the price index can be rewritten as

$$P_u = \left(N_u p_u^{1-\sigma}\right)^{\frac{1}{1-\sigma}} = N_u^{\frac{1}{1-\sigma}} p_u.$$

It can be readily seen that, when intermediate goods are more differentiated (low σ), the price index becomes less elastic with respect to the number of U-firms.[7] A decrease in the number of U-firms makes the intermediate goods more costly, but this effect declines as the varieties become more substitutable (high σ).

[7] To see this formally, the price elasticity is given by

$$-\frac{\partial \ln P_u}{\partial \ln N_u} = \frac{1}{\sigma - 1} > 0,$$

which decreases in σ.

Local downstream firms (D-firms). The cost function of D-firms is given by

$$C_d(q_d) = P_u \mu_d a q_d + \pi_d.$$

The D-firm needs $\mu_d a q_d$ units of intermediate inputs and one unit of *domestic* capital K, where a is the same parameter as that for U-firms and μ_d is an inverse measure of the efficiency of D-firms. π_d is the rental rate of domestic capital for D-firms. As a result of profit maximization, the D-firm sets its price at $p_d = \sigma P_u \mu_d a/(\sigma - 1) = \mu_d P_u$.

Multinational enterprises (MNEs). The cost function of MNEs is given by

$$C_m(q_m) = P_u \mu_m a q_m + \pi_m.$$

MNEs need $\mu_m a q_m$ units of intermediate inputs and one unit of *foreign* capital K_f. π_m is the rental rate of foreign capital for the MNEs. In parallel with D-firms, we have $p_m = \mu_m P_u$. In general, the level of technology differs between MNEs and D-firms, i.e., $\mu_m \neq \mu_d$. The total demand for the intermediate good I consists of the demand from D-firms and from MNEs, as follows:

$$I = N_d \mu_d a q_d + N_m \mu_m a q_m.$$

Foreign exporters (F-firms). The cost function for F-firms is given by

$$C_f(q_f) = w_f a(\tau q_f) + \pi_f,$$

where $\tau \geq 1$ is the iceberg trade costs and w_f is the wage rate in the foreign country. F-firms needs $a(\tau q)$ units of labor in the foreign country and one unit of foreign capital K_f. π_f is the rental rate of foreign capital for F-firms. We choose labor in the foreign country as the numéraire and, thus, have $w_f = 1$. As a result of the optimal pricing behavior and the choice of units, the F-firm's price is simply given by $p_f = \tau w_f a\sigma/(\sigma - 1) = \tau$.

3 Location equilibrium

Domestic capital K in the host country moves between *U-firms* and *D-firms*, in response to differences in the rate of returns. The capital share of D-firms is denoted by $n_d \in [0,1]$ and the capital share of U-firms by $n_u = 1 - n_d$. Thus, the number of D-firms (U-firms) can be rewritten as $N_d = n_d K$ ($N_u = n_u K$). Similarly, foreign capital K_f in the foreign country moves between *MNEs* and *F-firms*, responding to the return differential. The number of MNEs (F-firms) is given by $N_m = n_m K_f$ ($N_f = (1 - n_m)K_f$), where $n_m \in [0,1]$ represents the capital share of MNEs. We will explore the endogenous determination of domestic and foreign capital in turn.

3.1 The allocation of domestic capital

Let us first look at the allocation of domestic capital. Following Ottaviano et al. (2002), we employ a myopic adjustment process.[8] That is, if D-firms generate higher returns than U-firms, more capital is allocated to D-firms, and vice versa. The process is formulated as

$$\dot{n}_d = \begin{cases} \max\{0,\ \Delta\Pi_d\} & \text{if } n_d = 0 \\ \Delta\Pi_d & \text{if } n_d \in (0,1) \\ \min\{0,\ \Delta\Pi_d\} & \text{if } n_d = 1, \end{cases}$$

where the dot ($\dot{}$) represents the time derivative. $\Delta\Pi_d$ is the differential of domestic capital returns given by

$$\begin{aligned} \Delta\Pi_d &\equiv \pi_d - \pi_u \\ &= \frac{p_d q_d}{\sigma} - \frac{p_u q_u}{\sigma} \\ &= \frac{\alpha L}{\sigma}\left(\frac{P_u}{P}\right)^{1-\sigma}\left[\mu_d^{1-\sigma}\left(1 - \frac{aN_d}{N_u}\right) - \frac{a\mu_m^{1-\sigma}N_m}{N_u}\right], \end{aligned}$$

noting that the rental rate of domestic capital employed in each type of firm equals the operating profit of the firms.[9]

[8]We will relax this assumption and discuss results under forward-looking expectations in Section 6.3.

[9]From the first to the second line, we note that $\pi_u = (p_u - wa)q_u = waq_u/(\sigma - 1) = p_u q_u/\sigma$ holds because $p_u = wa\sigma/(\sigma - 1)$. An analogous relationship holds for π_d. From the second to the third line, we use $p_u/P_u = N_u^{\frac{1}{\sigma-1}}$.

The above equation implies that domestic capital moves from U-firms to D-firms if the following holds:

$$\begin{aligned}
&\dot{n}_d = \Delta\Pi_d \geq 0, \\
&\rightarrow \mu_d^{1-\sigma}\left(\frac{1}{\sigma} - \frac{aN_d}{\sigma N_u}\right) - \frac{a\mu_m^{1-\sigma}N_m}{\sigma N_u} \geq 0, \\
&\rightarrow n_m \leq \frac{K}{K_f(\sigma-1)}\left(\frac{\mu_m}{\mu_d}\right)^{\sigma-1}[\sigma - (2\sigma-1)n_d]. \qquad (2)
\end{aligned}$$

The dynamics of n_d is illustrated in Fig. 2, where the thick arrows indicate the direction of the movements of n_d. On the $\Delta\Pi_d = 0$ locus, where Eq. (2) holds with equality, domestic capital movements stop. To see why the locus has a downward slope in the (n_d, n_m) plane, consider a situation where, at first, the economy is on the $\Delta\Pi_d = 0$ locus and then an influx of MNEs pushes the economy upward from the locus (point "A" in Fig. 2). This expansion of MNE production boosts the demand for the intermediate inputs and, therefore, raises the profit of U-firms. To equalize profits between U-firms and D-firms, the upstream sector must host more U-firms and each U-firm therefore earns less, or equivalently, the downstream sector must host fewer D-firms and each D-firm earns more. This adjustment moves the economy leftward and the profits of the two types of firms are finally equalized on the locus.

The n_m intercept of the $\Delta\Pi_d = 0$ locus, denoted by n_m^o, can be derived as follows:

$$n_m^o \equiv \frac{\sigma K}{(\sigma-1)K_f}\left(\frac{\mu_m}{\mu_d}\right)^{\sigma-1}. \qquad (3)$$

In the following analysis, we assume that $n_m^o < 1$. In other words, the amount of foreign capital is larger than the amount of domestic capital ($K_f > K$) and/or MNEs have more efficient technology than do D-firms ($\mu_m < \mu_d$).[10]

Next, the n_d intercept of the $\Delta\Pi_d = 0$ locus, denoted by n_d^o, is derived as follows:

$$n_d^o \equiv \frac{\sigma}{2\sigma-1} \in \left(\frac{1}{2},\ 1\right). \qquad (4)$$

n_d^o is always valued between 0.5 and 1 because $\sigma > 1$. The remaining share of capital is allocated to U-firms and is thus given by $n_u^o = 1 - n_d^o = (\sigma-1)/(2\sigma-1)$. The corresponding amounts of capital are given by $N_d^o = n_d^o K$ and $N_u^o = n_u^o K$.

[10] We will relax this assumption in Section 6.1.

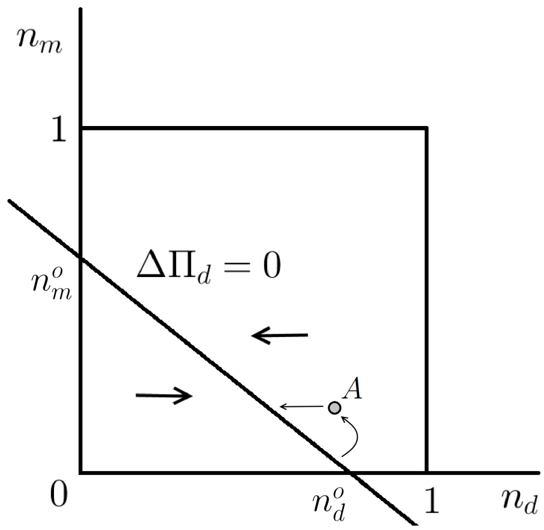

Fig. 2. Dynamics of n_d.

3.2 The allocation of foreign capital

The same analogy used for domestic capital is applied to foreign capital. The foreign capital K_f is allocated between MNEs and the F-firms. As in the case of domestic capital, its movement is governed by the following myopic process:

$$\dot{n}_m = \begin{cases} \max\{0,\ \Delta\Pi_m\} & \text{if } n_m = 0 \\ \Delta\Pi_m & \text{if } n_m \in (0,1) \\ \min\{0,\ \Delta\Pi_m\} & \text{if } n_m = 1, \end{cases}$$

where the differential of foreign capital returns $\Delta\Pi_m$ is given by

$$\begin{aligned} \Delta\Pi_m &\equiv \pi_m - \pi_f \\ &= \frac{\alpha L}{\sigma P^{1-\sigma}} \left(p_m^{1-\sigma} - p_f^{1-\sigma} \right). \end{aligned}$$

The share of foreign capital allocated to MNEs is denoted by $n_m \in [0,1]$ so that the capital share of F-firms is $n_f = 1 - n_m$. Thus, it holds that $N_m = n_m K_f$ and $N_f = n_f K_f$. Foreign capital moves from F-firms to MNEs if the following holds:

$$
\begin{aligned}
&\dot{n}_m = \Delta\Pi_m = \frac{\alpha L}{\sigma P^{1-\sigma}} \left(p_m^{1-\sigma} - p_f^{1-\sigma}\right) \geq 0, \\
&\to \mu_m^{1-\sigma} P_u^{1-\sigma} - \phi \geq 0, \\
&\to \mu_m^{1-\sigma} p_u^{1-\sigma} (1 - n_d) K - \phi \geq 0, \\
&\to n_d \leq 1 - \phi(\mu_m p_u)^{\sigma-1}/K \equiv f(\phi).
\end{aligned}
\tag{5}
$$

From the first to the second line in the derivation, we use $p_m = \mu_m P_u$ and $p_f^{1-\sigma} = \tau^{1-\sigma} \equiv \phi$, where ϕ denotes the freeness of trade ranging from zero (i.e., autarky, where $\tau = \infty$) to one (i.e., free trade, where $\tau = 1$). To investigate all possibilities, we consider a range of parameters allowing $\min f(\phi) = f(1)$ to take negative values.[11]

An increase in n_d affects p_m through changes in the price index of the intermediate inputs $P_u = (p_u^{1-\sigma} N_u)^{\frac{1}{1-\sigma}}$, which is a decreasing function of the number of U-firms (N_u). When MNEs make more profits than F-firms ($\Delta\Pi_m > 0$), there is a sufficiently large number of local suppliers, implying that $n_d = 1 - n_u$ is so small as to be less than $f(\phi)$.

As $f(\phi)$ does not involve n_m, the $\Delta\Pi_m = 0$ locus, where Eq. (5) holds with equality, is represented by a vertical line. Fig. 3 shows the $\Delta\Pi_m = 0$ locus, along with the arrows indicating the movement of n_m. As the exporters' price p_f becomes lower, the $\Delta\Pi_m = 0$ locus moves from the right to the left of Fig. 3. If p_f is extremely low (high ϕ) and, thus, exporting is highly profitable, no foreign capital is allocated to MNEs (shown by the right panel in Fig. 3).

[11] More precisely, we assume that $(\mu_m p_u)^{\sigma-1}/K > 1$.

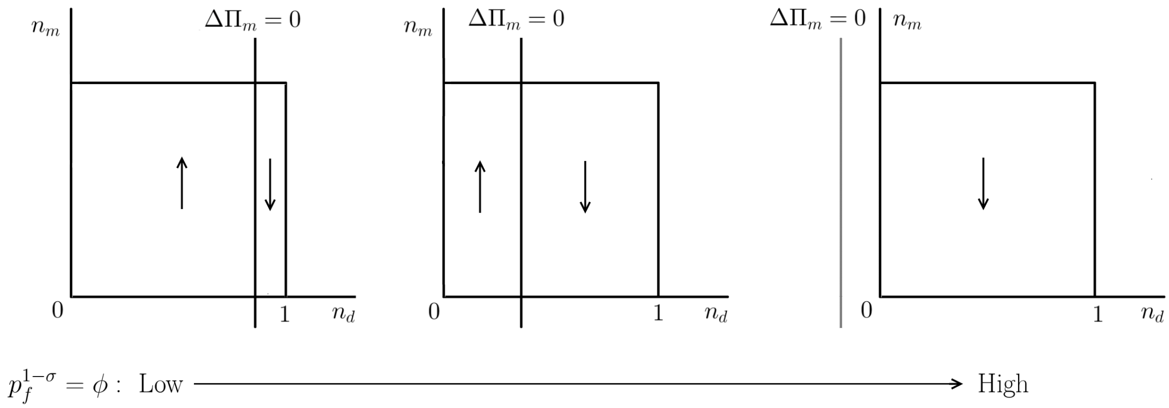

Fig. 3. Dynamics of n_m.

3.3 Equilibrium

To explore the steady-state equilibrium, where capital movement ceases, Fig. 4 combines Figs. 2 and 3 to illustrate the equilibria in the (n_d, n_m) plane for different levels of $p_f^{1-\sigma} = \phi$. We suppose that the host country experiences a gradual decline in trade costs from autarky to free trade, i.e., from $\phi = 0$ to $\phi = 1$.[12]

There are two possible corner equilibria: $S_1 : (n_d, n_m) = (0, 1)$, where MNEs dominate the host country's market; and $S_2 : (n_d, n_m) = (n_d^o, 0)$ (see Eq. (4)), where D-firms dominate. When the export price is extremely high as a result of high trade costs (low ϕ), the foreign country allocates all its capital to MNEs and directly serves the host market. When the export price is extremely low as a result of low trade costs (high ϕ), the foreign country allocates all its capital to F-firms. When the export price is in between the two extremes, i.e., trade costs are intermediate, whether it is profitable to become an MNE or an F-firm depends on the allocation of domestic capital and, thus, both of the corner equilibria are locally stable. The multiplicity of equilibria comes from the complementarity between MNEs and U-firms. More multinational production increases demand for local intermediate inputs, which attracts more domestic capital to the upstream sector. The expansion of the upstream sector reduces the input price, resulting in a further inflow of MNEs.

It is worth mentioning that the interior equilibrium U is saddle stable. As our model does not include any jump variables to put the economy on the saddle path, U is an unstable

[12]We implicitly assume that the speed at which the economy reaches steady-state equilibria is faster than the speed of trade cost reduction (a rise in ϕ). This enables us to highlight the impact of declining trade costs on the host economy at steady-state equilibria without investigating transitional dynamics.

equilibrium. The reason that there are only corner equilibria is the "footloose" nature of foreign capital, i.e., the fact that all foreign capital is allocated to either MNEs or F-firms, depending on the differences in their profits. Now, we start from the economy at U, where neither domestic nor foreign capital has an incentive to relocate between different sectors, i.e., $\Delta\Pi_d = 0$ and $\Delta\Pi_m = 0$. Then, we suppose that a tiny amount of domestic capital is moved from D-firms to U-firms. This trivial deviation from the interior equilibrium slightly lowers the price index of intermediate inputs, which makes it more profitable for foreign capital to become an MNE. Thus, the foreign capital in F-firms is ready to relocate to MNEs. This relocation in turn intensifies competition in the host country's final goods market and results in further movement of domestic capital from D-firms to U-firms. The capital movement continues until all domestic (foreign) capital is allocated to U-firms (MNEs). Once the economy deviates from the interior equilibrium, it never returns there.

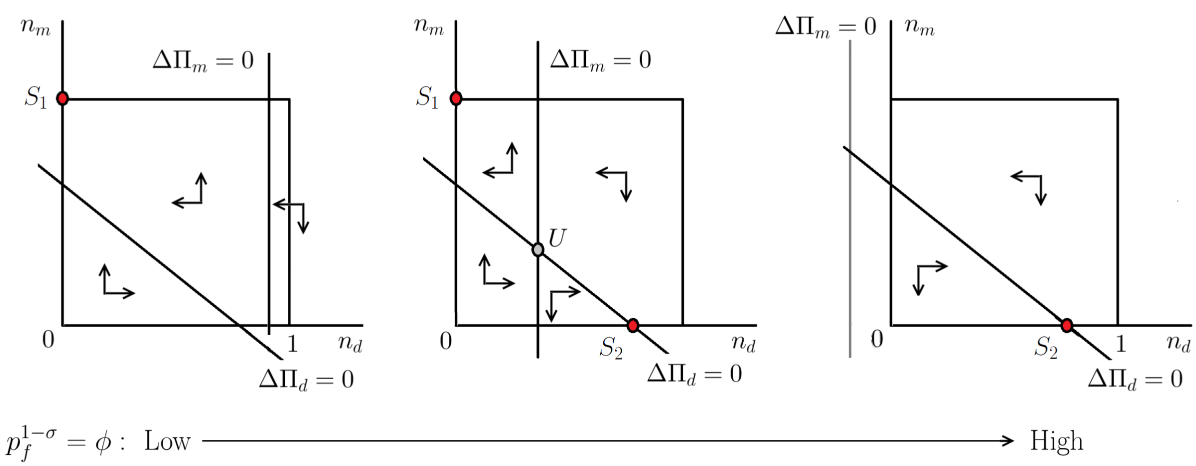

Fig. 4. Equilibria in the (n_d, n_m) plane.

Fig. 5 illustrates the equilibrium firm shares in terms of ϕ. We derive critical values of ϕ that switch the stability of the equilibria. The equilibrium S_2, where D-firms are dominant, becomes stable when ϕ is higher than a critical value of ϕ^*, where the $\Delta\Pi_d = 0$ locus and the $\Delta\Pi_m = 0$ locus intersect at S_2 in the (n_d, n_m) plane. The share of D-firms at S_2 is given by

$$n_d^o = 1 - \phi^*(\mu_m p_u)^{\sigma-1}/K,$$
$$\to \phi^* = (\mu_m p_u)^{1-\sigma} N_u^o.$$

The equilibrium S_1, in which MNEs are dominant, is no longer stable when ϕ is higher than a critical value of ϕ^{**}, where the $\Delta\Pi_m = 0$ locus coincides with the n_m axis in the (n_d, n_m) plane:

$$0 = 1 - \phi^{**}(\mu_m p_u)^{\sigma-1}/K,$$
$$\to \phi^{**} = (\mu_m p_u)^{1-\sigma} K.$$

As we suppose that there are gradual reductions in trade costs from $\phi = 0$ to $\phi = 1$, the host economy starts at S_1 and remains there until ϕ^{**} (see Fig. 5). Once ϕ becomes higher than ϕ^{**}, the economy suddenly switches from S_1 to S_2. We note that if exogenous shocks such as natural disasters hit the economy, then the equilibrium switch would occur even before ϕ reaches ϕ^{**}, as shown in the next section.

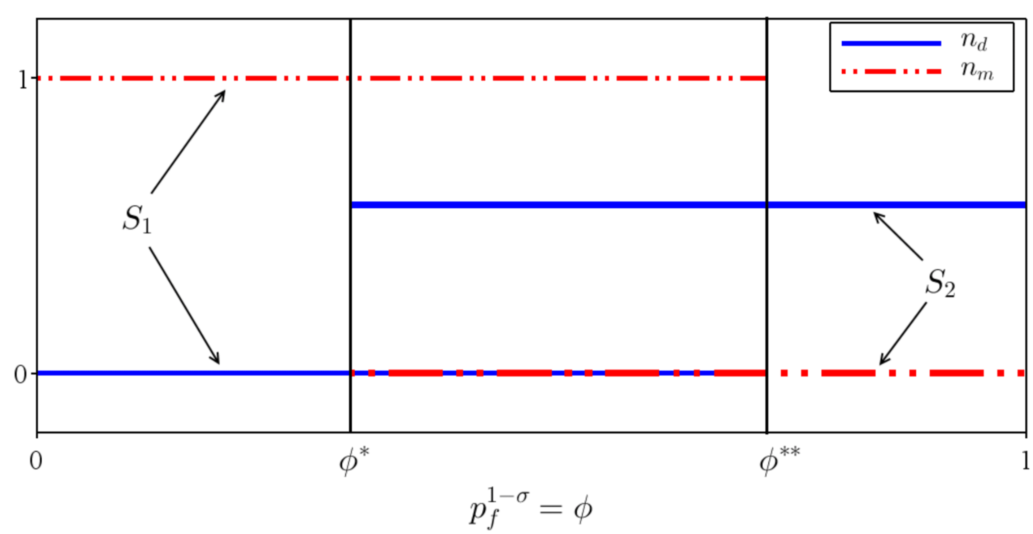

Fig. 5 Equilibrium firm shares.

We summarize the above discussion in Proposition 1.

Proposition 1 (Industrial configuration). *The equilibrium is characterized by*

(i) *With high trade costs, $\phi \in [0, \phi^*)$, multinational enterprises (MNEs) are dominant in the downstream sector, i.e., $S_1 : \ (n_d, n_m) = (0, 1)$.*

(ii) *With low trade costs, $\phi \in (\phi^{**}, 1]$, local firms (D-firms) are dominant in the downstream sector, i.e., $S_2 : \ (n_d, n_m) = (n_d^o, 0)$.*

(iii) *With intermediate trade costs, $\phi \in [\phi^*, \phi^{**}]$, either of the two configurations, S_1 or S_2, arises.*

The range of multiple equilibria is further investigated. The difference between ϕ^{**} and ϕ^* can be analytically expressed as

$$\phi^{**} - \phi^* = (\mu_m p_u)^{1-\sigma} N_d^o.$$

The difference is larger when (i) the amount of domestic capital (K) is larger, (ii) the technology of MNEs is more efficient ($1/\mu_m$ is smaller), and (iii) the price of an intermediate goods is lower ($p_u = w$ is smaller). A larger K and a smaller p_u lead to a lower price index for intermediate goods, whereas a smaller μ_m means that MNEs are more competitive than D-firms. In these cases, MNEs find it profitable to stay in the host country even if trade costs are sufficiently small. These results are summarized in Proposition 2.

Proposition 2 (Multiple equilibria). *The range of trade costs making multiple equilibria possible is wider if (i) the amount of domestic capital (K) is larger, (ii) the MNEs have a more advanced technology (μ_m is smaller), and (iii) the intermediate goods price (or the wage rate in the host country) is lower ($p_u = w$ is smaller).*

4 A sudden negative shock: Natural disaster

Now, we consider temporary negative shocks, such as natural disasters, in the host country. Large-scale natural disasters destroy capital, which is one of the most sizable impacts on the economy. As discussed in previous studies (e.g., Skidmore and Toya, 2002), countries that have suffered natural disasters rebuild capital and may even subsequently improve their economic performance. Based on these findings, we ask (i) whether natural disasters change the equilibrium configuration, and (ii) whether the welfare of the host country increases or decreases after natural disasters. This section explores question (i) and the next section examines question (ii).

Arguably, the most interesting case is that of multiple equilibria for intermediate trade costs, $\phi \in [\phi^*, \phi^{**}]$. Suppose that the host economy is at point S_1. Then, consider that a shock hits the host country and temporarily destroys domestic capital. This can be expressed as a temporary reduction of K. As Fig. 6 illustrates, a decrease in K shifts the $\Delta\Pi_d = 0$ locus downward and the $\Delta\Pi_m = 0$ locus leftward. If the negative shock is substantial, the $\Delta\Pi_m = 0$ locus shifts to the left side of the n_m axis. This makes S_1 unstable and leads the host country to the other equilibrium S_2.[13] The reduction of domestic capital decreases the number of U-firms and thereby raises the price index of intermediate goods. Owing to the higher sourcing costs, foreign capital finds it more profitable to move back to its source country and export final goods from there. Hence, the negative shock decreases the number of MNEs in the host country and, instead, increases F-firms in the foreign country. Importantly, the host economy stays at S_2 even after domestic capital has recovered to the preshock level. Although the shock is temporary, the host country switches from S_1 to S_2 permanently.

If a negative shock is so small that the $\Delta\Pi_m = 0$ locus is still located at $n_d > 0$ after the shock, S_1 remains stable and the capital allocation is unchanged.[14] For the equilibrium to switch, it is necessary that the negative shock is sufficiently large. Suppose that $\Delta K (< 0)$ denotes the loss of domestic capital, then the point S_1 is no longer stable if ΔK is smaller than $-\sigma\phi(\mu_m p_u)^{\sigma-1}/(\sigma - 1)$. The (absolute) level of the threshold increases in ϕ, μ_m, and p_u.[15]

The equilibrium switch resulting from the temporary negative shock is irreversible and one way. The host economy does not move from S_2 back to S_1 after capital recovers to the predisaster level over time. Furthermore, the host economy stays at S_2 even if recurrent natural disasters hit. To see this, suppose that the host economy is at S_2 and ϕ is in

[13] This corresponds to the case where the the economy shifts from the middle panel to the right panel in Fig. 4.

[14] See Section 6.1 for the case where small shocks change the equilibrium capital allocation.

[15] We note that the threshold is independent of the level of foreign capital K_f. Thus, the equilibrium switch occurs regardless of the amount of reductions in K_f. This result comes from the fact that a change in K_f does not affect the price index for intermediate goods and, thus, has no impact on the $\Delta\Pi_m = 0$ locus.

$[\phi^*, \phi^{**}]$. Again, natural disasters reduce the domestic capital, which shifts the $\Delta\Pi_m = 0$ locus leftward, as shown in Fig. 6. As the locus is always located at the left of S_2, the shift does not change the stability of S_2 and it never puts the economy on the equilibrium path leading to S_1. At S_2, a small number of U-firms hike up the price of intermediate inputs in the host country. Negative shocks further raise the input prices, which makes the host country much less attractive to MNEs. Thus, the recurrence of natural disasters never reverses the equilibrium.

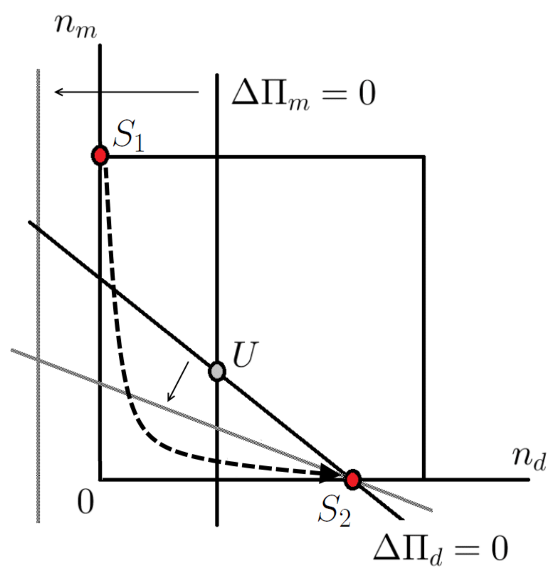

Fig. 6. Negative shock.

We summarize these findings in Proposition 3.

Proposition 3 (Natural disaster). *Suppose that trade costs are intermediate so that multiple equilibria arise, i.e.,* $\phi \in [\phi^*, \phi^{**}]$*, and the host economy is at* S_1*, where MNEs are dominant. A substantial reduction in domestic capital (*$\Delta K < -\sigma\phi(\mu_m p_u)^{\sigma-1}/(\sigma-1)$*) as a result of natural disasters permanently changes the equilibrium from* S_1 *to* S_2*, where local firms are dominant. This switch is (i) irreversible and (ii) one way, which indicates that (i) the economy never returns from* S_2 *to* S_1 *after the recovery and that (ii) recurrent natural disasters never push the economy from* S_2 *to* S_1*.*

5 Welfare and natural disaster

This section characterizes the welfare of the host country and the impact of a temporary negative shock. The individual welfare is measured by the real income per capita. Using equilibrium prices and profits, Eq. (1) can be rewritten as follows:

$$v = -\alpha \log P + (N_d \pi_d + N_u \pi_u)/L + w + \alpha(\log \alpha - 1).$$

The first term represents an inverse of the price index of final goods and the second term in parentheses is the income derived from domestic capital. As the third and fourth terms are constant, the welfare is determined by the price index and the capital income.

Our interest is in the two steady state equilibria, i.e., the point $S_1 : (n_d, n_m) = (0, 1)$ and the point $S_2 : (n_d, n_m) = (n_d^o, 0)$ where $n_d^o = \sigma/(2\sigma - 1)$ is defined in Eq. (4). We use the subscript $j \in \{1, 2\}$ to denote the equilibrium S_j. The profits of the U-firms and D-firms at S_j are, respectively, $\pi_{u,j}$ and $\pi_{d,j}$:

$$\pi_{u,1} = \frac{(\sigma - 1)\alpha L}{\sigma^2 K} \quad \text{for } \phi \in [0, \phi^{**}],$$
$$\pi_{u,2} = \pi_{d,2} = \frac{(\mu_d p_u)^{1-\sigma} N_u^o \alpha L}{\sigma[(\mu_d p_u)^{1-\sigma} N_u^o N_d^o + \phi K_f]} \quad \text{for } \phi \in [\phi^*, 1].$$

At S_1, where there are no D-firms, their profits $\pi_{d,1}$ are not defined. As all foreign capital is allocated to MNEs in the host country, $\pi_{u,1}$ is independent of ϕ. At S_2, where all foreign capital is allocated to F-firms, along with increasing ϕ, the F-firms penetrate the host market more intensively and, thus, the profits of the D-firms are reduced. In fact, we can confirm that $\pi_{u,1}$ is larger than $\pi_{u,2}$ for $\phi \in [\phi^*, \phi^{**}]$, as the left panel in Fig. 7 illustrates.

Similarly, the price indices of final goods are derived as follows:

$$P_1 = \mu_m p_u (K K_f)^{\frac{1}{1-\sigma}} \quad \text{for } \phi \in [0, \phi^{**}],$$
$$P_2 = [(\mu_d p_u)^{1-\sigma} N_u^o N_d^o + \phi K_f]^{\frac{1}{1-\sigma}} \quad \text{for } \phi \in [\phi^*, 1].$$

At S_1, where all final goods are produced by the MNEs, the price index does not depend on the trade freeness ϕ. At S_2, where consumers (partly) import final goods from the foreign country, the price index gets lower as ϕ increases and, thus, the imported goods become cheaper. Hence, we can check that the price index is higher at S_2 than at S_1 for a low ϕ, but this is reversed for a high ϕ as the right panel in Fig. 7 illustrates.

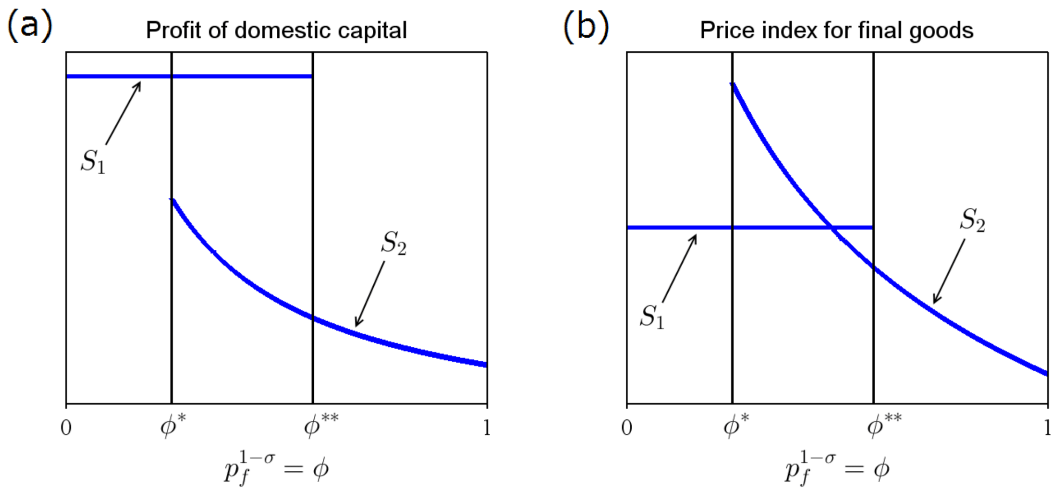

Fig. 7. (a) Domestic profits and (b) prices in the host country.

By combining operating profits with price indices, we can compare the welfare levels between the two equilibria, as shown in Fig. 8. At ϕ^*, S_1 yields higher profits and a lower price index than S_2. Hence, the host country is always better off at S_1 than at S_2. However, at ϕ^{**}, S_1 still yields higher profits but it has a higher price index than at S_2, implying that S_1 does not necessarily result in higher welfare than S_2. As mentioned above, the host country switches to the equilibrium at ϕ^{**}. The end result may be beneficial (Fig. 8(a)) or harmful (Fig. 8(b)) to welfare.

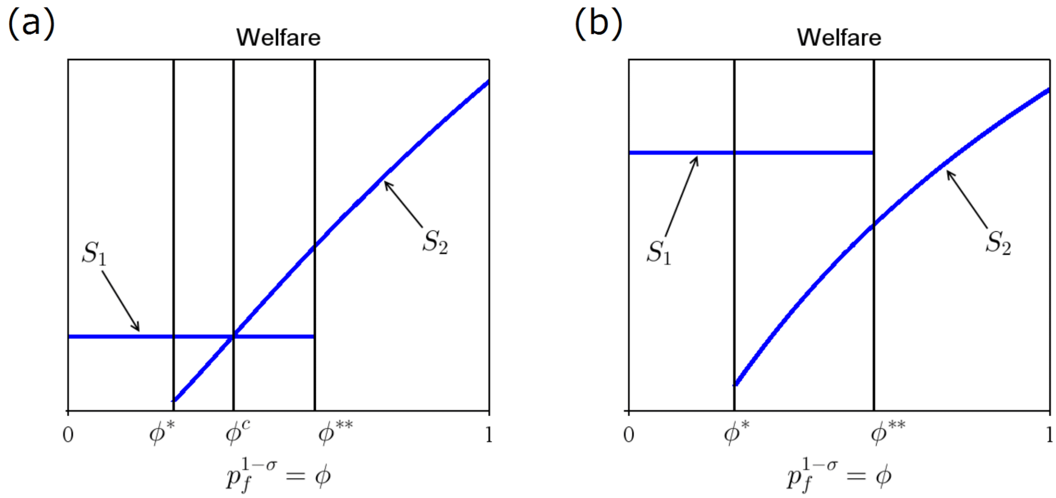

Fig. 8. Welfare of the host country.

Note: The equilibrium switch may be (a) beneficial or (b) is always harmful to welfare.

To explore the mechanism in more detail, we note that the equilibrium switch at ϕ^{**} would improve welfare if the fall in the price index of final goods is substantial. To see this, the ratio between price indices at the two equilibria is written as

$$\begin{aligned}\frac{P_2}{P_1} &= \frac{[(\mu_d p_u)^{1-\sigma} N_u^o N_d^o + \phi^{**} K_f]^{\frac{1}{1-\sigma}}}{\mu_m p_u (K K_f)^{\frac{1}{1-\sigma}}} \\ &= \left[\frac{(\mu_m p_u)^{1-\sigma} K K_f}{(\mu_d p_u)^{1-\sigma} N_u^o N_d^o + (\mu_m p_u)^{1-\sigma} K K_f}\right]^{\frac{1}{\sigma-1}} \\ &= \left[\frac{1}{n_u^o n_d^o (\mu_m/\mu_d)^{\sigma-1} (K/K_f) + 1}\right]^{\frac{1}{\sigma-1}} < 1,\end{aligned}$$

where $\phi^{**} = (\mu_m p_u)^{1-\sigma} K$. The ratio becomes smaller if μ_m and K are larger and if μ_d and K_f are smaller. As a result of the equilibrium switch, MNEs are replaced by D-firms and F-firms in the final goods market. This replacement lowers the final goods prices more if there is a more domestic capital relative to foreign capital (K/K_f is larger) and if the technological level of the D-firms is higher relative to that of the MNEs (μ_m/μ_d is larger). We summarize these results in Proposition 4.[16]

[16]More precise conditions can be found in Appendix 2.

Proposition 4 (Welfare). *When trade costs fall, the equilibrium switches from S_1 to S_2 at ϕ^{**}. This is beneficial to the host country if (i) the amount of domestic capital (K) is larger, (ii) the amount of foreign capital (K_f) is smaller, (iii) D-firms are more efficient ($1/\mu_d$ is larger), and (iv) MNEs are less efficient ($1/\mu_m$ is smaller).*

Based on Proposition 4, we derive the welfare implications of natural disasters. Following a natural disaster, the loss of domestic capital reduces the number of U-firms as well as the number of D-firms. The decreased number of suppliers in turn raises the price of intermediate inputs, causing MNEs to leave the host country. Responding to the decreased input demand from MNEs, more domestic capital moves to the downstream sector, whereas all foreign capital is allocated to F-firms. That is, the equilibrium switches from S_1 to S_2. If the conditions in Proposition 4 hold and trade costs are in $\phi \in [\phi^c, \phi^{**}]$, this capital replacement may substantially lower the price index for final goods, resulting in higher welfare than the predisaster level.[17] This situation can be referred to as a process of *creative destruction* of capital (Fig. 8(a)). The natural disaster results in higher welfare because the economy switches to the alternative equilibrium path, in which local firms and foreign exporters are favored over MNEs. On the other hand, if the conditions in Proposition 4 do not hold, a loss of domestic capital is always *destructive* to the welfare of the host country, and this situation can be referred to as a process of destructive destruction (Fig. 8(b)).

6 Extensions

This section provides three extensions of our basic model. The three extensions involve the analysis of the impacts of small negative shocks, subsidies to MNEs, and capital allocation by forward-looking decisions.

6.1 Small shocks

As shown in Section 4, large capital shocks cause the equilibrium industrial configuration to switch, but small shocks never affect the equilibrium. However, this result would be modified if we slightly relaxed our assumptions.[18] Proposition 3 suggests that major natural disasters

[17] ϕ^c is the trade freeness where $v_1 = v_2$ holds, as Fig. 8(a) shows.

[18] The detailed analysis is relegated to Appendix 3.

crowd out MNEs, which is empirically supported by some recent empirical studies (Escaleras and Register, 2011; Anuchitworawong and Thampanishvong, 2015). However, the opposite case could occur in reality, as it is possible that MNEs would be more likely to survive than local firms.

In Section 4, we assumed that the n_m intercept of the $\Delta\Pi_d = 0$ locus was smaller than unity, i.e., $n_m^o < 1$ (see Eq. (3)). At the equilibrium point S_1, we can observe that MNEs overtake the host market and no D-firms survive. By contrast, here we assume that $n_m^o > 1$. The $\Delta\Pi_d = 0$ locus and the $n_m = 1$ line intersect at the point with a positive n_d (the "interior" case). The assumption is likely to hold if K and μ_d are larger and if K_f and μ_m are smaller. This implies that the amount of domestic capital relative to that of foreign capital is large and/or the level of technology of D-firms relative to that of MNEs is high. Fig. 9 shows the $\Delta\Pi_d = 0$ locus, along with the arrows indicating the movement of n_d. However, this assumption does not alter the $\Delta\Pi_m = 0$ locus. Hence, all the dynamics of n_m behaves as they did in Fig. 3.

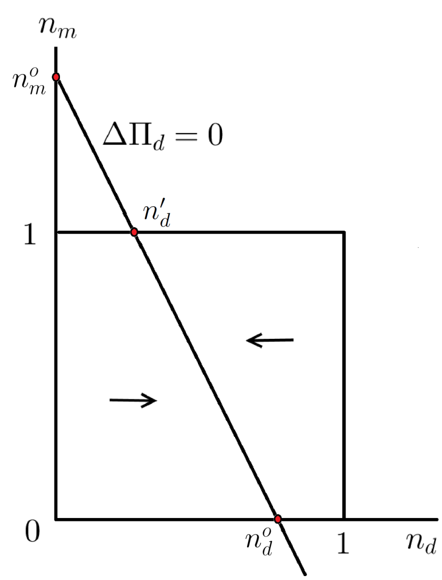

Fig. 9. Dynamics of n_d in the interior case.

Combining Fig. 9 with Fig. 3, Fig. 10 shows the steady-state equilibria in the (n_d, n_m) plane for different levels of ϕ, which corresponds to Figure 4 under $n_m^o < 1$. The equilibrium point S_1 now involves a positive share of D-firms. Under $n_m^o > 1$, the D-firms could survive even if all foreign capital goes to MNEs rather than F-firms. When trade costs are intermediate, multiple equilibria arise (the middle range of ϕ in Fig. 10).

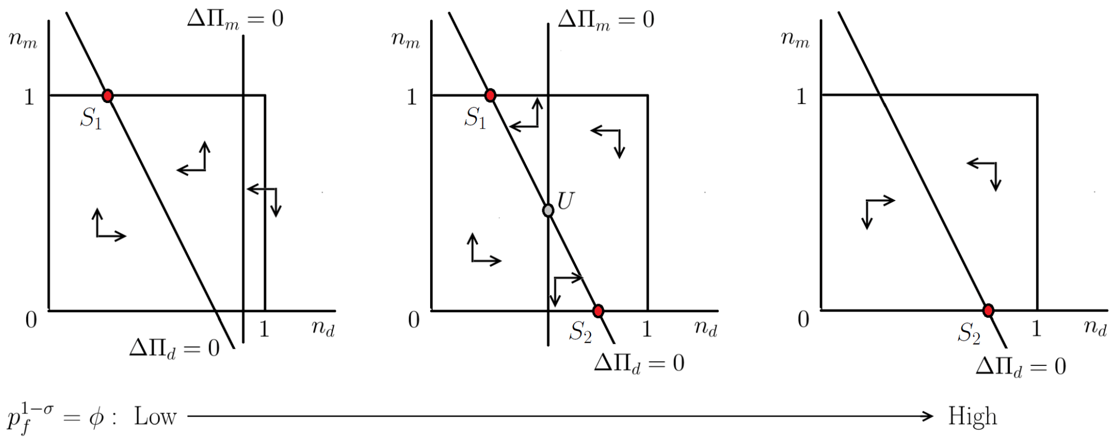

Fig. 10. Equilibria in the (n_d, n_m) plane in the interior case.

Following the analysis of Section 4, we start from the equilibrium at S_1 with an intermediate level of trade costs. Then, the damage resulting from a temporal negative shock reduces K by $\Delta K < 0$, which moves both the $\Delta\Pi_d = 0$ locus and the $\Delta\Pi_m = 0$ locus leftward, as shown in Fig. 11. Fig. 11(a) illustrates the case of small shocks. The shock is so small that the $\Delta\Pi_m = 0$ locus stays at $n_d > 0$ and S_1 remains (locally) stable. Less domestic capital is allocated to D-firms and, thus, the relative presence of MNEs in the downstream sector increases. A temporal shock causes a temporal change in the industrial configuration. After the economy recovers from the shock, the equilibrium returns to the preshock point.

As a comparison, Fig. 11(b) presents the case of substantial negative shocks, which were discussed in Section 4. As the $\Delta\Pi_m = 0$ locus crosses the n_m axis, S_1 is no longer stable and the economy switches from S_1 to S_2. The threshold of the shock size (the capital damage) above which Fig.11(b) emerges is given by $\Delta K < -\sigma\phi(\mu_m p_u)^{\sigma-1}/(\sigma-1)$; if the shock is below this size, we observe the situation shown by Fig. 11(a). This is isomorphic to Proposition 3. In summary, small negative shock temporarily decreases the number of D-firms, whereas a large shock permanently replaces D-firms with MNEs.

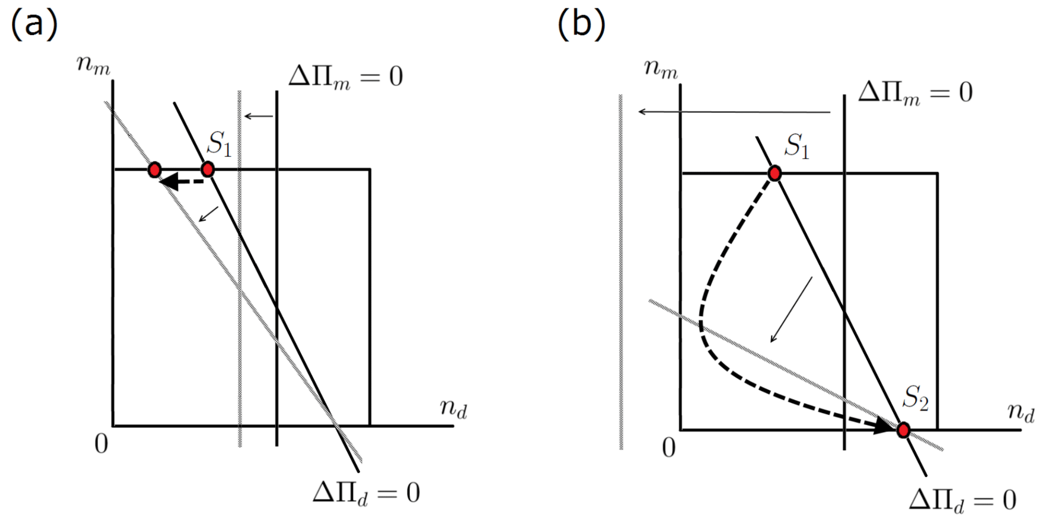

Fig. 11. Negative shocks in the interior case.

Note: The reduction of domestic capital is (a) small shock or (b) large.

Proposition 5 (Small shocks). *Assume that there is a positive share of D-firms at S_1 i.e., $n_m^o > 1$. If a temporal negative shock is small ($\Delta K \geq -\sigma\phi(\mu_m p_u)^{\sigma-1}/(\sigma-1)$), then the proportion of MNEs in the downstream sector temporarily increases relative to the proportion of D-firms. On the other hand, if the shock is substantial ($\Delta K < -\sigma\phi(\mu_m p_u)^{\sigma-1}/(\sigma-1)$), the temporal negative shock causes a permanent equilibrium switch from S_1 to S_2 as in Proposition 3.*

6.2 MNE subsidy

Many developing countries implement development strategies to attract MNEs. Here, we consider the implications of such a strategy. The relocation incentive of foreign capital to the host country now involves subsidies, as follows:

$$\dot{n}_m = \Delta\Pi_m = (1+z)\pi_m - \pi_f,$$

where $z > 0$ denotes the subsidy proportional to the operating profits of MNEs.[19]

[19] This formulation is equivalent to fixed cost subsidies, i.e., $C_m(q_m) = \mu_m a q_m + \pi_m/(1+z)$.

Accordingly, the critical points are rewritten as

$$\phi_z^* = (1+z)(\mu_m p_u)^{1-\sigma} N_u^o,$$
$$\phi_z^{**} = (1+z)(\mu_m p_u)^{1-\sigma} K,$$

where $N_u^o = n_u^o K$ is the same as the nonsubsidy case. Fig. 12 shows welfare levels at the two equilibria for different levels of subsidies (z).[20] An increase in z raises both ϕ^* and ϕ^{**} and expands the range of trade costs in the multiple equilibria. The subsidy softens the welfare deterioration caused by the equilibrium switch. Starting from ϕ^{**} in Fig. 12, the equilibrium switch does not occur in the case where there is an MNE subsidy, as shown in Fig. 12(b), with welfare remaining the level at S_1. Thus, the welfare deterioration caused by the equilibrium switch does not happen at ϕ^{**}. Then, even if trade costs are much lower, i.e. $\phi^{**} < \phi < \phi_z^{**}$, the host country stays at S_1. At ϕ_z^{**}, the equilibrium switches from S_1 to S_2. The welfare of the host country rises, in the process of creative destruction. In short, the MNE subsidies are more likely to prevent *destructive destruction* and to foster *creative destruction*.

Proposition 6 (MNE subsidy). *When the host country provides subsidies for the MNEs, two critical points ϕ_z^* and ϕ_z^{**} become higher and the gap between ϕ_z^* and ϕ_z^{**} becomes wider. Moreover, creative destruction is more likely to occur. The MNE subsidy could improve the host country's welfare in the case of temporary negative shocks.*

[20]The subsidies only affect the critical points and do not affect welfare levels because the host government does not collect taxes from the individuals for subsidy payment. If such taxes are considered, the horizontal line representing the welfare level at S_1 in Fig. 12(b) moves downward.

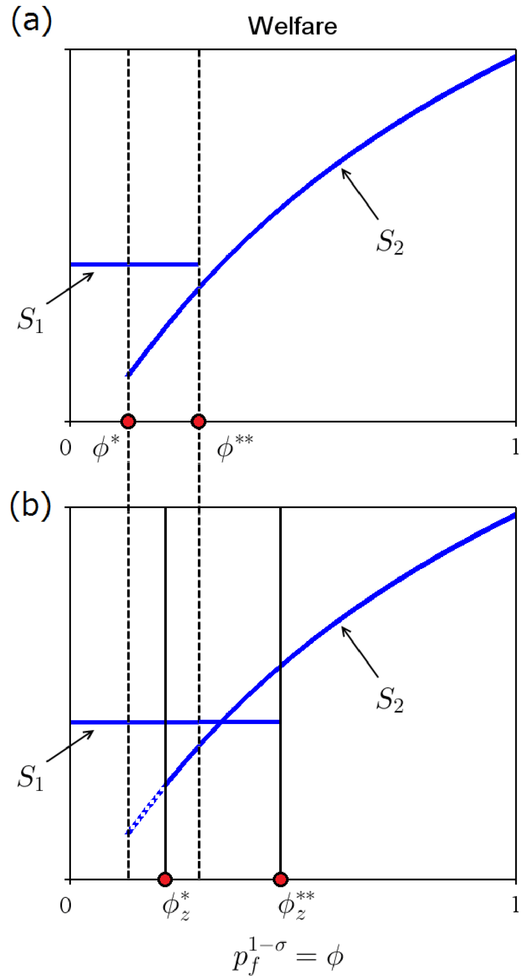

Fig. 12. The impact of MNE subsidy on welfare.

Note: (a) No subsidy ($z = 0$); (b) Positive subsidy ($z > 0$).

6.3 Forward-looking outcome

So far, we have assumed that equilibrium capital allocations are based on myopic decision-making. The current return (profit) differential determines the equilibrium capital allocation. Domestic (foreign) capital owners choose whether to invest in D-firms or U-firms (MNEs or F-firms). To generalize our analysis, we introduce the forward-looking decision-making, by assuming that capital is now allocated so as to maximize lifetime returns rather than current ones.

As in the myopic case, the stability of the equilibrium is determined by the two loci, i.e., $\Delta\Pi_d = 0$ and $\Delta\Pi_m = 0$, so that the forward-looking and myopic outcomes are identical if there is a unique stable equilibrium. That is, S_1 is chosen in the case of high trade costs (low trade freeness), $\phi < \phi^*$, and S_2 in the case of low trade costs (high trade freeness), $\phi > \phi^{**}$. The forward-looking decision-making results in a different outcome from the myopic decision-making in the case of multiple equilibria with $\phi \in [\phi^*, \phi^{**}]$. Under forward-looking decision-making, if either of the equilibria, S_1 or S_2, yields higher returns for both domestic and foreign capitals, capital owners in both types of capital agree on coordinating their behavior at the equilibrium.[21] We have already confirmed that returns for domestic capital are higher at S_1 than at S_2, as the left panel in Fig. 7 shows. Likewise, it is readily seen that S_1 yields higher returns than does S_2. Returns for foreign capital at the two equilibria are given by[22]

$$\pi_{m,1} = \frac{\alpha L}{\sigma K_f} \quad \text{for } \phi \in [0, \phi^{**}],$$
$$\pi_{f,2} = \frac{\phi \alpha L}{\sigma[(\mu_d p_u)^{1-\sigma} N_u^o N_d^o + \phi K_f]} \quad \text{for } \phi \in [\phi^*, 1],$$

where the subscript $j \in \{1, 2\}$ represents the equilibrium S_j. At S_1 (S_2), all foreign capital is allocated to MNEs (F-firms) and, thus, $\pi_{f,1}$ (or $\pi_{m,2}$) is not defined. At S_1, all domestic capital is allocated to U-firms, resulting in a lower price for intermediate inputs, whereas the MNEs are the only final goods producers and they enjoy the low intermediate input prices. Therefore, as the returns to both domestic and foreign capital are higher at S_1, the equilibrium under forward-looking decisions would be S_1 for $\phi \in [\phi^*, \phi^{**}]$.

When trade costs are intermediate, the forward-looking decision-making results in the same equilibrium, S_1, as does the myopic decision-making. However, the implications on the impact of natural disasters is different. Now, we suppose that there is a substantially large negative shock to domestic capital, as in Section 4. Temporary and permanent shocks give rise to different outcomes in the case of forward-looking decision-making, in contrast to the myopic case where the two types of shock generate the same outcome. If the shock is temporary, the equilibrium switch from S_1 to S_2 is temporary. Both domestic and foreign capital, anticipating the recovery, eventually move back to S_1, where they earn higher profits

[21]The equilibrium selection rule is known as the Pareto criterion in game theory. The criterion states that if a particular equilibrium is Pareto dominated by another, agents always choose the Pareto-dominant equilibrium. Hence, if one wishes to select between multiple equilibria with different payoffs, it is customary to adopt the Pareto criterion. See Baldwin (2001); and Baldwin et al. (2003, Ch.2) for an application to the economic geography model.

[22]See Appendix 1 for the derivation.

than at S_2. By contrast, if the shock is permanent, S_1 can no longer be a stable equilibrium. The equilibrium permanently switches to S_2.

Proposition 7 (Forward-looking outcome). *Suppose that capital is allocated by forward-looking capital owners and the host economy is at S_1 with $\phi \in [\phi^*, \phi^{**}]$. Consider a substantial negative shock to domestic capital ($\Delta K < -\sigma\phi(\mu_m p_u)^{\sigma-1}$). If the shock is permanent, the equilibrium permanently switches from S_1 to S_2. However, if the shock is temporary, the equilibrium shifts temporarily and eventually moves back to S_1. This is in sharp contrast to the case of myopic decision-making.*

7 Conclusion

This paper has developed a theoretical framework to address the impact of natural disasters on MNEs and welfare in the host country. Our focus is on two notable aspects of MNEs, footlooseness and the vertical linkages between upstream and downstream sectors. The first aspect gives rise to two extreme industrial configurations, one where 100% of foreign capital remains in the host country, and the other where all foreign capital is withdrawn. We found that the second aspect, the vertical linkages, may allow both of the configurations to be simultaneously stable. Once a massive natural disaster occurs, the industrial configuration switches from the equilibrium in which MNEs are dominant to the one in which domestic downstream firms are dominant. This may lower the final goods price and raise welfare, through the process known as creative destruction.

We believe that our model yields rich analytic outcomes, yet remains sufficiently simple to produce new insights into the nexus between natural disasters and multinationals. There are many ways to enrich further the analysis. For example, one can introduce technology spillovers from MNEs to domestic firms, especially local upstream suppliers. In brief, suppose that local suppliers benefit from positive technology spillovers from transactions with MNEs. Local firms produce intermediate goods at lower cost, which in turn benefits MNEs. By adding interindustry spillovers in such a way, linkages between local suppliers and MNEs would be intensified. Another possible extension is to consider MNEs in the upstream sector. Sophisticated inputs supplied by MNEs result in high-value-added products in the downstream sector. This analysis would yield implications for the global value chain in developing countries. We leave these issues to future research.

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Appendices

Appendix 1. Market clearing conditions

As all profits are distributed to factors, it must hold that $p_d q_d - C_d(q_d) = 0$; $p_m q_m - C_m(q_m) = 0$; and $p_u q_u - C_u(q_u) = 0$. These in turn imply the following relationship:

$$\begin{aligned}
&q_d = \sigma\pi_d/p_d = \frac{\sigma\pi_d}{\sigma P_u \mu_d a/(\sigma-1)} = \frac{\sigma\pi_d}{\mu_d P_u},\\
&q_m = \sigma\pi_m/p_m = \frac{\sigma\pi_m}{\sigma P_u \mu_m a/(\sigma-1)} = \frac{\sigma\pi_m}{\mu_m P_u},\\
&q_u = \sigma\pi_u/p_u = \frac{\sigma\pi_u}{\sigma w a/(\sigma-1)} = \frac{\sigma\pi_u}{w},\\
&N_u p_u q_u = P_u I, \quad p_u/P_u = N_u^{\frac{1}{\sigma-1}}, \quad I = N_u^{\frac{\sigma}{\sigma-1}} q_u,
\end{aligned}$$

where $a = (\sigma-1)/\sigma$ and $p_u = w$.

Final goods' market clearing condition states that the supply from D-firms, MNEs, and F-firms equal the consumers' demand in the host country:

$$N_d p_d q_d + N_m p_m q_m + N_f p_f q_f = \alpha L,$$
$$\to N_d \pi_d + N_m \pi_m + N_f \pi_f = \alpha L/\sigma. \tag{A1.1}$$

Similarly, the clearing condition for intermediate goods' market states that supply of U-firms must equal demand of D-firms and MNEs.

$$N_u p_u q_u / P_u = N_d \mu_d a q_d + N_m \mu_m a q_m,$$
$$\to N_u^{\frac{\sigma}{\sigma-1}} \cdot \frac{(\sigma-1)\pi_u}{wa} = N_d \mu_d a \cdot \frac{(\sigma-1)\pi_d}{\mu_d a P_u} + N_m \mu_m a \cdot \frac{(\sigma-1)\pi_m}{\mu_m a P_u},$$
$$\to N_u^{\frac{\sigma}{\sigma-1}} (\sigma \pi_u / w) \cdot P_u = (\sigma-1)(N_d \pi_d + N_m \pi_m),$$
$$\to N_u \sigma \pi_u / (\sigma-1) = N_d \pi_d + N_m \pi_m. \tag{A1.2}$$

To derive profits at S_1, we substitute $N_d = 0$ and $N_m = K_f$ into (A1.1) and (A1.2), where only π_d and π_m are defined. Similarly, profits at S_2 are derived by (A1.1) and (A1.2) evaluating at $N_d = n_d^o K$ and $N_m = 0$, where π_m is not defined.

Appendix 2. Welfare

We compare the welfare of the host country welfare at S_1, denoted by v_1, with the one at S_2, denoted by v_2. The welfare differential at $\phi^{**} = K(\mu_m p_u)^{1-\sigma}$ can be written as

$$v_2 - v_1 = -\alpha \ln P_2 + \pi_{u,2}(K/L) - [-\alpha \ln P_1 + \pi_{u,1}(K/L)] < 0,$$
$$\to \ln(P_1/P_2) \equiv \ln(\Delta_1/\Delta_2)^{\frac{1}{1-\sigma}} > K(\pi_{u,1} - \pi_{u,2})/(\alpha L),$$
$$\to \ln(\Delta_1/\Delta_2) < -K(\sigma-1)(\pi_{u,1} - \pi_{u,2})/(\alpha L),$$
$$\to \Delta_1/\Delta_2 < \exp\left[-K(\sigma-1)(\pi_{u,1} - \pi_{u,2})/(\alpha L)\right],$$
$$\text{where } \ \Delta_1 \equiv (\mu_m p_u)^{1-\sigma} K K_f, \quad \Delta_2 \equiv (\mu_d p_u)^{1-\sigma} N_u^o N_d^o + (\mu_m p_u)^{1-\sigma} K K_f,$$

where $\pi_{u,1}$ and $\pi_{u,2}(= \pi_{d,2})$ are defined in Section 5.

Using the Taylor approximation, we can rewrite the inequality as follows:

$$\begin{aligned}
&\Delta_1/\Delta_2 < 1+\Theta, \\
&\to \frac{(\sigma-1)(2\sigma-1)}{\sigma^2} < \frac{K}{K_f}\left(\frac{\mu_m}{\mu_d}\right)^{\sigma-1}, \\
&\text{where} \ \ \Theta \equiv -K(\sigma-1)(\pi_{u,1}-\pi_{u,2})/(\alpha L).
\end{aligned}$$

The above inequality is likely to hold if K and μ_m are larger and if K_f and μ_d are lower.

Appendix 3. Interior configuration

In the main analysis, we assume that the n_m intercept of $\Delta\Pi_d = 0$ locus is smaller than unity, i.e., $n_m^o < 1$ (see Eq. (3)). Consequently, at the equilibrium point S_1, we can observe that MNEs take the host market and no D-firms survive. Section 6.1, by assuming the contrary, i.e., $n_m^o > 1$, explores the case where some D-firms survive:

$$n_m^o \equiv \frac{\sigma K}{(\sigma-1)K_f}\left(\frac{\mu_m}{\mu_d}\right)^{\sigma-1} > 1.$$

This is likely to hold if K and μ_m are larger and if K_f and μ_d are smaller. Using the expression of n_m^o, the intersection between $n_m = 1$ and the $\Delta\Pi_d = 0$ locus, denoted by n_d', can be expressed as follows:

$$n_d' \equiv \frac{\sigma(n_m^o - 1)}{n_m^o(2\sigma-1)} < 1.$$

The n_d intercept of the $\Delta\Pi_d = 0$ locus, denoted by n_d^o, is identical with the one in the text:

$$n_d^o \equiv \frac{\sigma}{2\sigma-1} \in \left(\frac{1}{2},\ 1\right).$$

Noting that the $\Delta\Pi_m = 0$ locus remains the same as in the case of $n_m^o < 1$, Fig. A.1 plots the steady-state equilibria in terms of ϕ, which corresponds to Fig. 5. The critical values of ϕ determining the stability of equilibrium are derived as follows:

$$\begin{aligned}
\phi^* &= (\mu_m p_u)^{1-\sigma} N_u^o, \\
\phi^{**} &= (\mu_m p_u)^{1-\sigma} N_u',
\end{aligned}$$

where $N_u^o \equiv (1 - n_d^o)K$ and $N_u' \equiv (1 - n_d')K$. As ϕ gets higher ($\phi \in (\phi^{**}, 1]$), the equilibrium changes from the one with the MNEs being dominant to the one with the D-firms being dominant and in the meantime ($\phi \in [\phi^*, \phi^{**}]$) multiple equilibria arise. These qualitative natures of steady-state equilibrium are the same as in the case of $n_m^o < 1$.

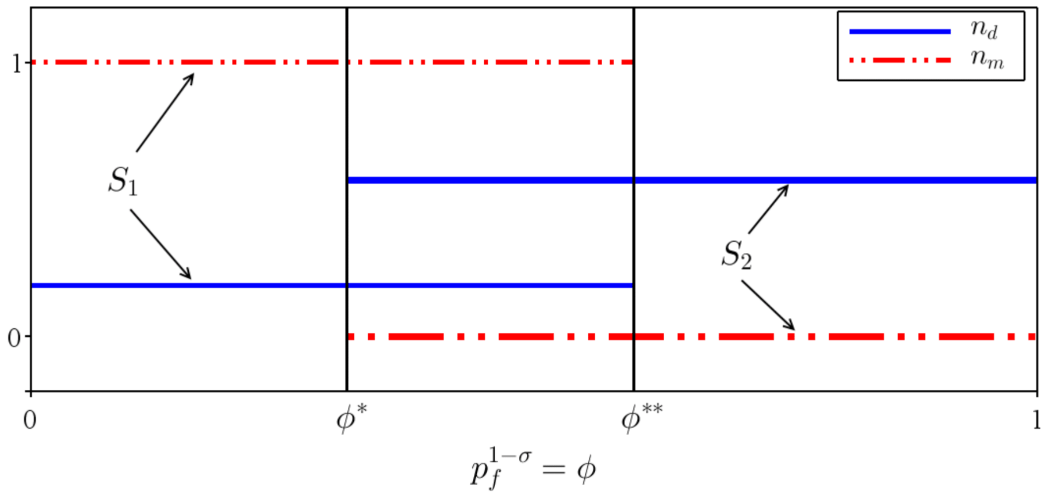

Figure. A1.
Equilibrium firm shares in the interior case ($n_m^o > 1$).

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