# Mergers and the Composition of International Commerce

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## 1 Introduction

Foreign Direct Investment (FDI) occurs when firms from one country own and operate productive assets in another. A domestic firm may enter a foreign market by buying existing plants (cross-border mergers and acquisitions) or by opening new facilities (greenfield FDI). As figure 1 shows, the preferred mode of entry, over the last twenty years, into the U.S. manufacturing industries has been mergers and acquisitions (M&A) rather than greenfield FDI. The relative importance of cross-border M&A has been remarkably stable over time: in every year from 1981 to 2001, between 75% and 90% of all new foreign affiliates in U.S. manufacturing have been acquired through M&A, while only 10%-25% have been established through greenfield FDI. The importance of M&A as a mode of foreign market access is not limited to the United States. The United Nations Center for Transnational Corporations (1999) reports that the vast majority of FDI globally takes the form of cross-border M&A.

Interestingly, despite the predominance of cross-border M&A, the theoretical literature in International Trade has focused almost exclusively on models of greenfield FDI. This omission is important because cross-border M&A and greenfield FDI are unlikely to be perfect substitutes for most firms seeking to expand abroad. The inability of multinationals to acquire existing plants in a host country may substantially restrict the total volume of FDI into that location. For instance, Lawrence (1993) argues that institutional factors that prevent foreign firms to buy existing Japanese plants explains the low level of FDI into Japan relative to other large developed countries.

In this paper, we fill the gap in the literature by presenting a much richer model of FDI that incorporates both greenfield FDI and cross-border M&A as distinct modes of foreign market access. In our model, M&A arise endogenously by the desire of firms to exploit "synergies" in their underlying capabilities. It is a widespread belief that synergies are a key motivation for firms to merge. Evidence to support this belief has accumulated in recent years as researchers have gained access to establishment-level datasets. For instance, using U.S. data both Lichtenberg and Siegel (1987) and McGuckin and Nguyen (1995) show that establishments undergoing control changes display increases in productivity relative to those establishments that did not. Baldwin (1995) presents similar evidence for Canadian establishments. A particularly intriguing result of Baldwin's analysis is that M&A were most efficiency-enhancing in those industries

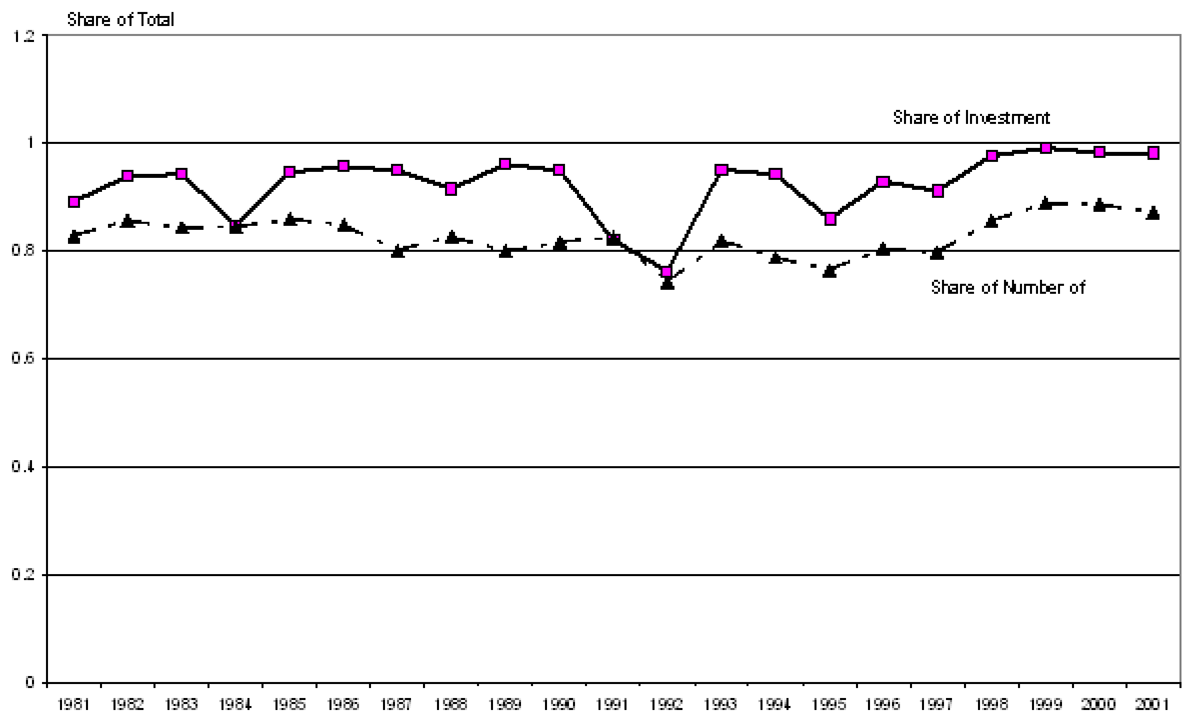


Figure 1: Acquisitions in total manufacturing FDI.

in which foreign ownership is most prevalent, suggesting that FDI is highly concentrated in those industries in which synergy-driven M&A are common.

For M&A to be driven by synergies, there must be some heterogeneity in the distribution of capabilities across firms, and these capabilities must be complementary. For instance, one firm may be better in the production of goods while the other may be better in marketing. Other forms of heterogeneity across firms may be unique to an international context. For instance, one obvious source of heterogeneity are asymmetric capabilities with respect to national markets: American firms may have an advantage producing in America rather than in Japan since they have accumulated a greater stock of knowledge about the production environment in America. The importance of M&A in FDI suggests that heterogeneity in firm capabilities is crucial in understanding the composition of international commerce. We therefore posit that firms differ in their endowment of complementary capabilities and that these capabilities can be partitioned into a subset of those that are perfectly mobile internationally and a subset of those that are location-specific. Firms are randomly assigned an initial endowment of these capabilities and then may buy or sell capabilities in a competitive market, which we refer to as the merger market. The random assignment of endowments of capabilities generates M&A even within the same country. The fact that some of these capabilities are not perfectly mobile internationally generates a distinct motive for cross-border M&A. Consequently, the types of firms created through cross-border M&A may be different from the types of firms established through pure domestic M&A.

The conceptual difference between cross-border M&A and greenfield FDI is that the former involves trading scarce capabilities, while the latter does not. Therefore, greenfield FDI is restricted to the set of activities that do not rely on scarce local capabilities. We think of this set of activities as the assembly of intermediate inputs, while the production of those intermediate inputs does require immobile capabilities. Consequently, the level of integration into the host country is lower under greenfield FDI than under cross-border M&A. Indeed, this is supported by empirical evidence. Andersson and Fredriksson (2000) show that plants established through greenfield FDI rely much more heavily on intermediate inputs imported from the source country than do plants acquired through M&A.

In addition to cross-border M&A and greenfield FDI, our model allows for a third mode of foreign market access: exporting. Exporting involves production of the intermediate inputs and their assembly in the home country, and shipping the final good abroad. In contrast, greenfield FDI requires that only the intermediate inputs be shipped abroad, while cross-border M&A allows complete integration into the foreign market and, hence, does not necessitate shipping goods to the foreign country. Consequently, both modes of FDI are associated with lower transport costs and tariffs than exporting. To keep the model tractable, we have decided to abstract from "vertical" FDI and instead to follow the literature on "horizontal" FDI, where all FDI is ultimately motivated by firms' incentives to save on transport costs and tariffs. This modeling choice may be justfied by the fact that most FDI, and in particular most cross-border M&A, is between similarly endowed, industrialized countries.

In our model, the behavior of firms in the merger market and their choice of mode of foreign market access are jointly determined. In equilibrium, different types of firms choose different modes of market access. Crucially for empirical work, the within-industry composition of international commerce depends on both country and industry characteristics. With respect to country characteristics, we show that market size is a key determinant of the within-industry composition of international commerce across countries. The fact that market size matters in our framework is interesting because large-group, fixed-markup monopolistic competition models of exports and FDI, such as the model presented in this paper, are generally unable to generate such effects (see for instance, Helpman, Melitz, and Yeaple (2003)). With respect to industry characteristics, we analyze the effects of transport costs and tariffs, and the magnitude of fixed costs associated with multinational production via both greenfield FDI and cross-border M&A. Of additional empirical interest are our results on the systematic efficiency differences between those M&A that are purely domestic and those that have a cross-border component.

An important feature of our model is that the degree of heterogeneity in the perfectly mobile and imperfectly mobile capabilities is a critical industry determinant of the equilibrium within-industry composition of international commerce. Depending on whether the perfectly mobile capabilities are more or less heterogeneous than the imperfectly mobile capabilities, those firms that ultimately engage in cross-border M&A may either be the most or the least efficient active firms. In contrast, firms engaging in greenfield FDI will always be more efficient than exporters. To the extent that industries vary in terms of their production technology and hence the relative importance of capabilities, the within-industry composition of international commerce can be expected to vary considerably across industries. This suggests caution in micro-data empirical work that investigates the sorting of firms to modes of foreign market access.[1]

We also show that the relative degrees of heterogeneity across capabilities are important in understanding the effects of country and industry characteristics on observed industry-level efficiencies. For instance, we show that when perfectly mobile capabilities are more heterogeneous than imperfectly mobile capabilities, inefficient firms are more likely to survive in large markets than in small markets while the opposite is true when imperfectly mobile capabilities are more heterogeneous than perfectly mobile capabilities. These results are relevant for cross-country studies of industry-level productivity, such as Harrigan (1997, 1999). Further, the implication of falling transport costs (or tariffs) is similarly dichotomous: whether falling transport costs raise or lower observed aggregate industry efficiency turns on the relative degree of heterogeneity in the two sets of capabilities. These results are useful to a growing empirical literature that attempts to quantify the productivity implications of increasingly free trade across countries (see, for instance, Bernard, Jensen, and Schott (2003)).

*Related literature.* The importance of firm heterogeneity has recently begun to receive attention in the International Trade literature. Examples of recent work in this literature are the papers by Bernard et al. (2000), Melitz (2002), and Helpman, Melitz, and Yeaple (2003). These models are similar to ours in that different firm types choose, in equilibrium, different modes of market access. However, since inter-firm heterogeneity is confined to one dimension and a firm's endowment of its capability is perfectly mobile across countries, these models do not allow for cross-border M&A.

Our paper contributes to the industrial organization literature on endogenous horizontal

[1] This literature is still in its infancy but promises to be an important area of research. See, for instance, Doms and Jensen (1998), Bernard and Jensen (1999), and Head and Ries (2002).

mergers. In contrast to our paper, this literature has mainly been concerned with market power as the driving force of mergers, and with the limits of monopolization through acquisition (e.g., Kamien and Zang (1990), Nocke (2000)). One notable exception is the paper by Jovanovic and Rousseau (2002), where acquisitions are modeled as the outcome of a stochastic productivity process in which firms receiving bad technology shocks sell their capacity to more efficient firms. The literature on cross-border M&A is still in its infancy, and authors in this literature have also focused on market power as the motivation for mergers (e.g., Head and Ries (1997), Horn and Persson (2001), Neary (2003)).[2]

## 2 The Model

We consider a (partial equilibrium) model of international trade with two countries, a home country ($h$) and a foreign country ($f$). The aggregate income levels in the home and foreign countries are denoted by $I^h$ and $I^f$, respectively. We assume that the two countries are of similar size so that $|I^h - I^f|$ is small. The countries are identical in all other respects. In particular, the price of labor is the same in both countries, and normalized to 1.[3]

*Preferences.* The representative consumer spends a fraction $\beta$ of her income on the differentiated goods sector. She has CES preferences over the differentiated good, and so her utility can be written as

$$X^k = \left[\int_{\Omega^k} x(\omega)^\rho d\omega\right]^{\frac{1}{\rho}}, \quad \rho = \frac{\sigma - 1}{\sigma},\ \sigma > 1, \tag{1}$$

where $x(\omega)$ is the level of consumption of variety $\omega$, and $\sigma$ the elasticity of substitution across varieties.

*Technology and Firms.* The final good is produced from labor and an intermediate input, using a constant-returns-to-scale technology. Specifically, the production function is given by

$$f(L, N) = BL^{1-\lambda}N^\lambda,\ \lambda \in (0, 1),$$

where $L$ is the quantity of labor used and $N$ the amount of the intermediate input, and

$$B = \lambda^\lambda(1 - \lambda)^{1-\lambda}.$$

The production of the intermediate input requires the use of scarce capabilities as well as labor. The production function of the intermediate in country $k \in \{h, f\}$ is

$$N(L_N, \widetilde{y}^k, \widetilde{z}) = L_N\widetilde{y}^k\widetilde{z},$$

where $L_N$ is the quantity of labor used, $\widetilde{y}^k \geq 0$ the firm's immobile capability, specific to country $k$, and $\widetilde{z} \geq 0$ the firm's mobile capability. Mobile and immobile capabilities are complementary in the production of the intermediate input. Immobile capabilities might include

[2] An important early contribution on exogenous cross-border mergers is Markusen (1984). He analyzes the exogenous merger of two competing national firms and the resulting welfare effects.

[3] The assumption of equal wages can be rationalized by the existence of an outside good that is produced by both countries and requires only labor.

the knowledge of country-specific market conditions (e.g., the quality of the established networks with input suppliers) or the quality of the "team" of immobile local managers. Mobile capabilities might include the perceived quality of the product variety, proprietary production technology, corporate management, and other types of mobile organization capital.

Capabilities can only be used by one firm at any time, and production of the intermediate has to be undertaken within the firm.[4] In contrast to a firm's immobile capabilities, a firm's mobile capability $\widetilde{z}$ can be used in both countries simultaneously. A firm owning a collection of capabilities, can use no more than one capability of each type (immobile capability in each country, and mobile capability). Therefore, a firm can be defined by its ownership of its best mobile and immobile capabilities, $\{\widetilde{y}^h, \widetilde{y}^f, \widetilde{z}\}$, and by its home country. For convenience, we call a firm's home country the country in which the firm's capability $\widetilde{z}$ was originally (i.e., upon entry) created.

A firm may or may not produce the final good and the intermediate in the same country, and may or may not export the final good to the other country. If firms ship the final output or the intermediate input from one country to another, iceberg-type transportation costs have to be incurred: for one unit to arrive in the foreign country, $\tau > 1$ units need to be shipped. The existence of these transportation costs (or tariffs) makes the cost of serving a market sensitive to the location of production. If the intermediate input and final good are produced in country $k \in \{h, f\}$, the marginal cost of production is

$$c(\widetilde{y}^k\widetilde{z}) = \begin{cases} \left(\widetilde{y}^k\widetilde{z}\right)^{-\lambda} & \text{if } \widetilde{y}^k\widetilde{z} > 0, \\ \infty & \text{otherwise.} \end{cases}$$

If the intermediate input and final good are produced in country $k$ and then shipped to country $k' \neq k$, the marginal cost of serving country $k'$ is $\tau c(\widetilde{y}^k\widetilde{z})$. Finally, if the intermediate input is produced in country $k$ and then shipped to country $k' \neq k$, where it is combined with labor to produce the final good, the marginal cost of serving country $k'$ is given by $\tau^\lambda c(\widetilde{y}^k\widetilde{z})$.

In addition to the variable costs discussed above, fixed (corporate management) costs have be incurred if production takes place in a country other than the firm's "home country". The fixed cost associated with managing the production of the intermediate input abroad is $F_N$. Similarly, the fixed cost associated with managing the assembly of the final good abroad is $F_A$. Consequently, for managing both the production of the intermediate input and the final assembly in the foreign country, the firm has to incur a fixed cost of $F_N + F_A$. These fxed costs of managing production abroad imply that a domestic firm will never conduct a production activity abroad that it does not also conduct at home.

For notational convenience, we will henceforth work with the following transforms of our primitives, $\widetilde{y}^k$, $\widetilde{z}$, and $\tau$:

$$\begin{aligned} y^k &\equiv \left(\widetilde{y}^k\right)^{\lambda(\sigma-1)}, \\ z &\equiv \widetilde{z}^{\lambda(\sigma-1)}, \\ \text{and } T &\equiv \tau^{-(\sigma-1)}. \end{aligned}$$

[4] We are thus not allowing firms to outsource production.

The benefit of this transformation is that a firm's profit is linear in these redefined variables. Note that $T < 1$ is inversely related to $\tau$, while $y^k$ and $z$ are positively related to $\widetilde{y}^k$ and $\widetilde{z}$.

*Entry.* There is a continuum of (atomistic) potential entrants, each of which is endowed with the know how to produce a unique variety. Entrants can only enter the market in their own country. If they decide to do so, they have to pay an (irrecoverable) entry fee $F_e$. After a firm has paid the entry cost, it gets a random draw of its (local) immobile production capability ($y^k \geq 0$ for an entrant in country $k \in \{h, f\}$), and of its mobile capability ($z \geq 0$). A new entrant in country $k$ is assumed to have no capabilities specific to the other country, i.e., $y^{k'} = 0$ for $k' \neq k$.

We assume that capabilities of an entrant in country $k$, $y^k$ and $z$, are independently distributed. For simplicity, we will restrict attention to two polar cases. A critical feature of both polar cases is that the "good" mobile and immobile capabilities are scarce.

**Model I** There is heterogeneity in firms' mobile capabilities ($z$), while the distribution of firms' immobile capabilities ($y^k$) is degenerate. More precisely, for an entrant in country $k \in \{h, f\}$,

$$\begin{aligned} y^k &= \begin{cases} 1 & \text{with probability } \mu, \\ 0 & \text{with probability } 1-\mu, \end{cases} \\ z &\sim H(\cdot) \text{ continuous on } [0, \infty). \end{aligned}$$

**Model II** There is heterogeneity in firms' immobile capabilities ($y^k$), while the distribution of firms' mobile capabilities ($z$) is degenerate. More precisely, for an entrant in country $k \in \{h, f\}$,

$$\begin{aligned} z &= \begin{cases} 1 & \text{with probability } \nu, \\ 0 & \text{with probability } 1-\nu, \end{cases} \\ y^k &\sim G(\cdot) \text{ continuous on } [0, \infty). \end{aligned}$$

Each firm can produce only one variety due, for instance, to entrepreneurs' limited span of control (Lucas (1978)). Moreover, any capability can productively be used only by a single firm.

*Merger Market.* After firms have entered the market, their endowment of capabilities can be traded in a perfectly competitive merger market. The equilibrium value (or profit) of a firm in home market $k$ with capabilities $\{y^h, y^f, z\}$ can be decomposed as

$$\Pi(y^h, y^f, z, k) = V^h(y^h) + V^f(y^f) + W^k(z),$$

where $V^k(y)$ is the market price for capability $y$ in country $k$, and $W^k(z)$ the market price of capability $z$ in country $k$. While a firm is identified by the ownership of its capabilities (and its home country), we do not need to identify the "owner" of the firm who is buying or selling capabilities on the merger market. However, it may be convenient for the reader to identify a firm's ownership with its mobile capability $z$ (and so only the immobile capabilities are traded on the merger market, while $W^k(z)$ is the shadow value of $z$).

*Firms and the Post-Merger Location of Production.* As we will show in the next section, all firms will locate the production of the intermediate input and the assembly of the final good in their home country. Firms will therefore serve their home market entirely from local production. Firms differ, however, in the extent to which they locate production abroad. We can then label firms according to their location of production as follows.

1. National firms. These firms produce the intermediate input and assemble the final good in their in their own country, where they own an immobile capability.

2. Multinational firms created through cross-border mergers. These firms produce the intermediate input and assemble the final good in both countries since they own an immobile capability both at home and abroad. They do not engage in any cross-border trade.

3. Multinational firms created through greenfield FDI. These firms produce the intermediate input and assemble the final good in their domestic country, where they own an immobile capability. In addition, they ship the intermediate input abroad, where they assemble the final good for the local market. They do not ship the final good.

In equilibrium, there will never be firms which produce the intermediate input abroad but do no also assemble the final good abroad.

*Product Market Competition.* Since there is a continuum of atomistic firms (each facing a downward-sloping demand curve), we may think of firms as either setting prices or quantities. We allow firms to discriminate between markets, so that they can set different prices (or quantities) for the two countries.

*Timing.* The timing of the model may be summarized as follows.

**Entry Stage** In each country, potential entrants decide whether or not to enter the market.

**Merger Stage** Firms participate in the merger market (as buyers or sellers), and decide where to locate production (incurring the associated fixed costs).

**Output stage** Firms compete in prices (or quantities) and receive profits.

*Equilibrium.* Formally, the model may be cast as an anonymous game. We seek the subgame perfect equilibrium of this game.

# 3 Equilibrium Analysis: The Composition of International Commerce

In this section, we turn to the equilibrium analysis of our model and determine the equilibrium pattern of export, greenfield FDI, and international mergers. First, we will consider the polar case, where the heterogeneity in local immobile capabilities is degenerate in that $y^k \in \{0, 1\}$. Then, we will analyze the other polar case, where the heterogeneity in mobile capabilities is degenerate in that $z \in \{0, 1\}$.

Solving the representative consumer's utility maximization problem, we obtain the following demand for any variety in the market of country $k$:

$$x^k(\omega) = \beta I^k \left(P^k\right)^{\sigma-1} p^k(\omega)^{-\sigma},$$

where $p^k(\omega)$ is the price of variety $\omega$ in country $k$, and

$$P^k = \left[\int_{\Omega^k} p^k(\omega)^{1-\sigma} d\omega\right]^{\frac{1}{1-\sigma}}$$

the aggregate price index in country $k$.

Let $\widehat{c}^k(\omega)$ denote the marginal cost of *selling* variety $\omega$ in country $k$, inclusive of the (iceberg-type) transportation cost (if any). Recall that firms can price-discriminate between countries. Profit maximization then implies that each firm charges a fixed markup, and so $p^k(\omega) = \widehat{c}^k(\omega)/\rho$. Hence, the gross profit of a firm selling variety $\omega$ in country $k$ is given by

$$S^k \left(\widehat{c}^k(\omega)\right)^{1-\sigma},$$

where the markup-adjusted residual demand level $S^k$ is given by

$$S^k = \frac{\beta I^k}{\sigma} \left[\int_{\Omega^k} \widehat{c}^k(\omega)^{1-\sigma} d\omega\right]^{-1}. \tag{2}$$

It is straightforward to show that the cross-country differences in the market prices of capabilities are arbitrarily small, given that the two countries are of sufficiently similar size. It then follows that a firm will never do a set of activities (production of the intermediate, assembly of the final good) abroad without doing the same activities at home. To see this, note that the firm could just switch the set of activities (including the ownership of the immobile capabilities) from one country to the other, and increase its profit by saving on the fixed costs ($F_A$ or $F_N$), whereas all other components of profits will only change by an arbitrarily small amount. Hence, a firm will always serve its home market by locating production of the intermediate input and final assembly at home. Firms will thus only differ in their way of serving the foreign market. A firm will never produce the intermediate input abroad without also assembling the final good abroad as this would require the firm to incur transportation costs twice: once by shipping the intermediate input back to the home country for final assembly, and again by shipping the final good abroad. The firm could do strictly better by replicating the production of the intermediate at home. Hence, we are left with three modes of foreign market access. In increasing order of integration into the foreign market, these are given by: (i) export of the final good; (ii) export of the intermediate input, and final assembly in the foreign market (greenfield FDI), and (iii) production of the intermediate input and final assembly in the foreign market (cross-border merger).

The differences in the degree of integration into country $k$ are reflected by the extent to which transportation costs affect gross profits. The gross profit of a firm with capabilities

$\{y^h, y^f, z\}$ that is generated in country $k$ is given by

$$\begin{array}{ll} S^k T y^{k'} z & \text{for production and assembly in country } k' \neq k, \\ S^k T^\lambda y^{k'} z & \text{for production in country } k' \neq k, \text{ but local assembly}, \\ S^k y^k z & \text{for local production and assembly}, \end{array}$$

where $T = \tau^{1-\sigma} < 1$.

### 3.1 Model I: Heterogeneity in Mobile Capabilities

We first consider model I, where mobile capability $z$ is heterogeneous across firms and the distribution of firms' immobile capabilities $y^k$ is degenerate. Specifically, for an entrant in country $k \in \{h, f\}$, $z$ is drawn from the continuous and strictly increasing distribution function $H(\cdot)$ with density $h(\cdot)$ and support $[0, \infty)$, while $y^k = 1$ with probability $\mu$ (independently of the realization of $z$), and $y^k = 0$ otherwise.

Since the immobile capability $y^k = 0$ cannot be used for production, its market value must be zero, i.e., $V^k(0) = 0$. In equilibrium, firms with different mobile capabilities $z$) will take different actions in the merger market. Since each active firm needs exactly one mobile capability $z$, it is convenient to consider the optimal decisions of a firm at the merger stage, conditional on owning a particular $z$ in country $k$. Her payoff from exporting is

$$\pi_x^k(z) = \left(S^k + S^{k'} T\right) z - V^k(1),\ k' \neq k,$$

where $V^k(1)$ is the opportunity cost of using (or the actual cost of purchasing) the domestic immobile capability $y^k = 1$. If, instead, she decides to purchase both a domestic $y^k = 1$ and a foreign $y^{k'} = 1$ (cross-border M&A), she obtains a payoff of

$$\pi_m^k(z) = \left(S^k + S^{k'}\right) z - V^k(1) - V^{k'}(1) - F_A - F_N,\ k' \neq k,$$

where $F_A$ and $F_N$ are the fixed costs of managing the assembly of the final good and the production of the intermediate input abroad. Finally, if she decides to engage in greenfield investment abroad, her expected payoff is

$$\pi_g^k(z) = \left(S^k + S^{k'} T^\lambda\right) z - V^k(1) - F_A,\ k' \neq k.$$

At the beginning of the merger stage, the value of a firm with mobile capability $z$ in country $k$ is thus

$$W^k(z) = \max\left\{0, \pi_x^k(z), \pi_m^k(z), \pi_g^k(z)\right\}.$$

Since $W^k(z)$ is piecewise linear in $z$ with

$$0 < \frac{d\pi_x^k(z)}{dz} < \frac{d\pi_g^k(z)}{dz} < \frac{d\pi_m^k(z)}{dz},$$

and

$$\pi_m^k(0) < \pi_g^k(0) < \pi_x^k(0) < 0,$$

there exist thresholds $z_0^k$, $z_1^k$, and $z_2^k$ such that a firm with capability $z$ in country $k$ will be inactive if $0 \leq z < z_0^k$, engaged in exporting abroad if $z_0^k \leq z < z_1^k$, engaged in greenfield FDI if $z_1^k \leq z < z_2^k$, and engaged in cross-border M&A if $z \geq z_2^k$. Hence,

$$W^k(z) = \begin{cases} 0 & \text{if } z \in [0, z_0^k], \\ \pi_x^k(z) & \text{if } z \in [z_0^k, z_1^k], \\ \pi_g^k(z) & \text{if } z \in [z_1^k, z_2^k], \\ \pi_m^k(z) & \text{if } z \in [z_2^k, \infty). \end{cases} \tag{3}$$

It is straightforward to see that some firms (namely those with high $z$) will always engage in cross-border mergers. However, parameters may be such that no firm engages in greenfield investment or exporting. Below, we provide sufficient conditions on the fixed costs that ensure that, in equilibrium, there is a positive mass of firms engaging in greenfield FDI, in exporting, and in cross-border M&A. Henceforth, we restrict attention to this parameter space, and so $0 < z_0^k < z_1^k < z_2^k$. In this case, the thresholds are given by

$$z_0^k = \frac{V^k(1)}{S^k + S^{k'}T}, \tag{4}$$

$$z_1^k = \frac{F_A}{S^{k'}(T^\lambda - T)}, \tag{5}$$

$$z_2^k = \frac{V^{k'}(1) + F_N}{S^{k'}(1 - T^\lambda)}. \tag{6}$$

Firms that decide to export are thus less efficient than firms that engage in FDI (through either greenfield investment or cross-border mergers). On the one hand, exports require lower fixed costs (as no foreign production or assembly need to be managed and no foreign immobile capability be purchased). On the other, transport costs have to be incurred for each unit shipped abroad, and so the marginal increase in payoff from raising mobile capability $z$ is lower than with FDI. For similar reasons, greenfield investment involves less efficient firms than cross-border mergers.

*Merger market equilibrium.* We now consider equilibrium in the merger market. Since each entrant is "borne" with one mobile capability $z$, and each active firm needs only one $z$, we may restrict attention to the merger market for immobile capabilities.

Let $M^k$ denote the mass of entrants in country $k$. Since the probability of $y^k = 1$ for a new entrant is equal to $\mu$, the supply (through entry) of immobile capabilities of type $y^k = 1$ in country $k$ is $\mu M^k$. Each active domestic firm needs an immobile capability of type $y^k = 1$, and so the domestic demand is $M^k \left[1 - H(z_0^k)\right]$. Moreover, all foreign entrepreneurs who decide to engage in cross-border M&A also require a domestic immobile capability of type $y^k = 1$, and so the foreign demand is $M^{k'} \left[1 - H(z_2^{k'})\right]$. The clearing condition for the merger market in country $k$ is thus given by

$$M^k \left[\mu + H(z_0^k) - 1\right] = M^{k'} \left[1 - H(z_2^{k'})\right], \; k' \neq k. \tag{7}$$

Note that foreign buyers of domestic immobile capabilities in the merger market tend to be more efficient (in that they have higher $z$'s) than domestic buyers: foreign buyers are all firms with $z \geq z_2^{k'}$, while domestic buyers are those domestic firms with $z \geq z_0^k$ who received a $y^k = 0$ upon entry. We now claim that for the merger market to clear the market price of a viable immobile capability must be positive: $V^k(1) > 0$. To see this, note that the right-hand side of the merger market clearing condition, (7), is positive. Since $\mu < 1$, for the left-hand side to be positive as well, we must have $z_0^k > 0$, and so, from (4), $V^k(1) > 0$.

*Free entry.* We now turn to firm behavior at the entry stage. Since each potential entrant in country $k$ has the option of not entering and earning zero profits, in equilibrium, potential entrants must be indifferent between entering and not entering. We thus have

$$\mu V^k(1) + \int_0^\infty W^k(z)dH(z) - F_e = 0. \tag{8}$$

Using (3), the expected value of the mobile capability $z$ is given by

$$\begin{aligned}
\int_0^\infty W^k(z)dH(z) &= \int_{z_0^k}^{z_1^k} \pi_x^k(z)dH(z) + \int_{z_1^k}^{z_2^k} \pi_g^k(z)dH(z) + \int_{z_2^k}^{\infty} \pi_m^k(z)dH(z) \\
&= S^k\Psi(z_0^k) + S^{k'}\left\{T\Psi(z_0^k) + (T^\lambda - T)\Psi(z_1^k) + (1-T^\lambda)\Psi(z_2^k)\right\} \\
&\quad -V^k(1)\left[1 - H(z_0^k)\right] - F_A\left[1 - H(z_1^k)\right] \\
&\quad -\left(V^{k'}(1) + F_N\right)\left[1 - H(z_2^k)\right],
\end{aligned} \tag{9}$$

where

$$\Psi(z_i) \equiv \int_{z_i}^\infty z dH(z).$$

It will prove useful to rewrite the demand level $S^k$, defined by (2), as

$$S^k = \frac{\beta I^k}{\sigma}\left[M^k\Psi(z_0^k) + M^{k'}\left\{T\Psi(z_0^{k'}) + (T^\lambda - T)\Psi(z_1^{k'}) + (1-T^\lambda)\Psi(z_2^{k'})\right\}\right]^{-1}. \tag{10}$$

*Equilibrium.* Equilibrium in model I can now be formally defined as the collection of endogenous variables for each country $k$, $\left\{V^k(\cdot), W^k(\cdot), M^k, S^k, z_0^k, z_1^k, z_2^k\right\}_{k\in\{h,f\}}$, satisfying equations (4) to (10).

**Remark 1** *We have defined equilibrium* assuming *that each of the three modes of foreign market access (export, greenfield FDI, cross-border M&A) is chosen by some firms in equilibrium. It is straightforward to define equilibrium more generally. While* any *equilibrium has the property that there exist thresholds* $0 \leq z_0^k \leq z_1^k \leq z_2^k$ *such that a firm with mobile capability* $z$ *in country* $k$ *will be inactive if* $0 \leq z < z_0^k$*, engaged in exporting abroad if* $z_0^k \leq z < z_1^k$*, engaged in greenfield FDI if* $z_1^k \leq z < z_2^k$*, and engaged in cross-border M&A if* $z \geq z_2^k$*, parameter values may be such that* $z_i^k = z_{i+1}^k$ *for* $i \in \{0,1,2\}$ *in equilibrium. It is straightforward to find sufficient conditions that ensure that each of the three modes of market access is chosen by some firms in equilibrium. For instance, if the fixed cost of entry,* $F_e$*, is sufficiently small and the fixed cost of managing the production of the intermediate good abroad,* $F_N$*, sufficiently large, then* $z_0^k < z_1^k < z_2^k$*.*

### 3.2 Model II: Heterogeneity in Immobile Capabilities

We now turn to model II, where immobile capabilities ($y^k$) are heterogeneous across firms and the distribution of firms' mobile capabilities ($z$) is degenerate. Specifically, for an entrant in country $k \in \{h, f\}$, $y^k$ is drawn from the continuous distribution function $G(\cdot)$ with density $g(\cdot)$ and support $[0, \infty)$, while $z = 1$ with probability $\nu$ (independently of the realization of $y^k$), and $z = 0$ otherwise.

Since a mobile capability with $z = 0$ cannot be used for production, its market value must be zero, i.e., $W^k(0) = 0$. Consider now a firm which already owns a mobile capability of type $z = 1$ in country $k$. The firm may decide to export, the maximum payoff of which is

$$\Pi_x^k = \max_y \left\{ \left[ S^k + S^{k'} T \right] y - V^k(y) \right\}.$$

Let $Y_x^k$ denote the set of immobile capabilities that will be used, in equilibrium, for exports. The firm must be indifferent between each of these immobile capabilities, and so

$$\frac{dV^k(y)}{dy} = S^k + S^{k'} T \quad \text{for all } y \in Y_x^k.$$

Alternatively, the firm may decide to engage in greenfield investment abroad. The maximum payoff of this mode of foreign market access is

$$\Pi_g^k = \max_y \left\{ \left[ S^k + S^{k'} T^\lambda \right] y - V^k(y) \right\} - F_A.$$

Denoting by $Y_g^k$ the set of immobile capabilities that will be used for greenfield investment, we must have

$$\frac{dV^k(y)}{dy} = S^k + S^{k'} T^\lambda \quad \text{for all } y \in Y_g^k,$$

to ensure that the firm is indifferent between all the immobile capabilities in $Y_g^k$. Finally, the firm may decide to engage in cross-border M&A, the maximum payoff of which is given by

$$\Pi_m^k = \max_y \left\{ S^k y - V^k(y) \right\} + \max_y \left\{ S^{k'} y - V^{k'}(y) \right\} - F_A - F_N.$$

Note that this payoff is independent of the firm's home country, i.e., $\Pi_m^k = \Pi_m^{k'}$. Denoting by $Y_m^k$ the set of immobile capabilities that will be used for cross-border mergers, we must have

$$\frac{dV^k(y)}{dy} = S^k \quad \text{for all } y \in Y_m^k.$$

Next, note that

$$0 < \left. \frac{dV^k(y)}{dy} \right|_{y \in Y_m^k} < \left. \frac{dV^k(y)}{dy} \right|_{y \in Y_x^k} < \left. \frac{dV^k(y)}{dy} \right|_{y \in Y_g^k}.$$

Assuming $W^k(1) > 0$ (which holds in equilibrium), we must have $V^k(y) = 0$ for $y$ sufficiently small. That is, the least efficient immobile capabilities will not be used in equilibrium. Combining these observations, it follows that there are thresholds $y_0^k$, $y_1^k$, and $y_2^k$, such that all immobile capabilities $y^k \in [0, y_0^k)$ are not used in equilibrium, all $y^k \in [y_0^k, y_1^k) = Y_m^k$ are used for cross-border mergers, all $y^k \in [y_1^k, y_2^k) = Y_x^k$ are employed for exports to country $k' \neq k$, while all $y^k \in [y_2^k, \infty) = Y_g^k$ are used for greenfield investment. Hence, in contrast to the model in section 3.1 with heterogeneity in $z$ and homogeneity in $y^k$, the firms engaging in cross-border mergers are the least efficient active firms. If one capability is of varying quality, then firms would optimally like to spread the best capabilities over as many units as possible. Cross-border mergers allow mobile capabilities to be used in both countries, whereas country-specific immobile capabilities will only be employed in one country. Hence, if there is heterogeneity in the immobile capabilities (and homogeneity in the mobile capabilities), then cross-border mergers will involve worse capabilities than exports and greenfield investment. In the previous model, the reverse is true. What remains true is that firms engaging in greenfield investment are more efficient than those who decide to export as the same immobile capability may be used in both countries with positive probability.

For simplicity, we restrict attention to the subset of the parameter space where, in both countries, there are some firms who engage in each of the three modes of foreign market access. That is, $Y_m^k$, $Y_x^k$, and $Y_g^k$ are non-empty, and so

$$0 < y_0^k < y_1^k < y_2^k.$$

Hence, in both countries, firms who own a mobile capability of type $z = 1$ are indifferent between exporting, greenfield investment, and cross-border M&A, which implies

$$W^k(1) = \Pi_x^k = \Pi_g^k = \Pi_m^k,\ k \in \{h, f\}.$$

Moreover, since the payoff from cross-border mergers is independent of the firm's home country, $\Pi_m^k = \Pi_m^{k'}$, the value of the mobile capability must be the same in both countries:

$$W^k(1) = W^{k'}(1) \equiv W(1).$$

The market price for immobile capabilities, $V^k(y)$, can then be written as follows:

$$V^k(y) = \begin{cases} 0 & \text{if } y \leq y_0^k, \\ S^k\left(y - y_0^k\right) & \text{if } y \in \left[y_0^k, y_1^k\right) = Y_m^k, \\ S^k\left(y - y_0^k\right) + S^{k'}T\left(y - y_1^k\right) & \text{if } y^k \in \left[y_1^k, y_2^k\right) = Y_x^k, \\ S^k\left(y - y_0^k\right) + S^{k'}T\left(y - y_1^k\right) \\ \quad + S^{k'}(T^\lambda - T)\left(y - y_2^k\right) & \text{if } y^k \in \left[y_2^k, \infty\right) = Y_g^k. \end{cases} \tag{11}$$

The thresholds $y_i^k$ are thus given by

$$y_0^k = \frac{W(1) + F_A + F_N - S^{k'} y_0^{k'}}{S^k}, \tag{12}$$

$$y_1^k = \frac{S^{k'} y_0^{k'} - F_A - F_N}{S^{k'} T}, \tag{13}$$

$$y_2^k = \frac{F_A}{S^{k'}(T^\lambda - T)}. \tag{14}$$

*Merger market equilibrium.* We are now in the position to consider equilibrium in the merger market. Any cross-border merger involves exactly one immobile capability from each country. In country $k$, the mass of immobile assets used for cross-border mergers is $M^k \left[G(y_1^k) - G(y_0^k)\right]$. Hence, for market clearing, we must have

$$M^k \left[G(y_1^k) - G(y_0^k)\right] = M^{k'} \left[G(y_1^{k'}) - G(y_0^{k'})\right]. \tag{15}$$

Moreover, the market for mobile capabilities must clear as well. The world supply of mobile capabilities of type $z = 1$ is $\nu \left(M^k + M^{k'}\right)$. On the demand side, the number of firms in country $k$ engaging in exporting or greenfield investment is $M^k \left[1 - G(y_1^k)\right]$. In addition, in the two countries together, there is a mass $M^k \left[G(y_1^k) - G(y_0^k)\right] = M^{k'} \left[G(y_1^{k'}) - G(y_0^{k'})\right]$ of firms involved in cross-border mergers. Hence, in equilibrium,[5]

$$M^k \left[1 - \nu - G(y_0^k)\right] = -M^{k'} \left[1 - \nu - G(y_1^{k'})\right], \; k' \neq k. \tag{16}$$

When the two countries are identical, foreign buyers purchase less efficient domestic immobile capabilities in the merger market than domestic buyers: foreign buyers purchase $y^k \in [y_0^k, y_1^k)$, while domestic buyers (who are those firms who received a $y^k < y_0^k$ upon entry) purchase $y^k \in [y_0^k, \infty)$. Since some firms obtain a bad draw of $z$ upon entry, immobile capabilities of type $z = 1$ are scarce, and so must have a positive market value: $W(1) > 0$. This positive market value provides an incentive for entrants who obtained a sufficiently small $y$ but a good $z$ $(z = 1)$ to sell their $z$ to a firm with a higher $y$.

*Free entry.* In equilibrium, the value of a new entrant must be equal to zero. This free entry condition can be written as

$$\nu W(1) + \int_0^\infty V^k(y) dG(y) - F_e = 0, \tag{17}$$

where

$$W(1) = S^k y_0^k + S^{k'} y_0^{k'} - F_A - F_N, \tag{18}$$

$$\int_0^\infty V^k(y) dG(y) = S^k \Phi(y_0^k) + S^{k'} T \Phi(y_1^k) + S^{k'} (T^\lambda - T) \Phi(y_2^k), \tag{19}$$

and

$$\Phi(y_i) \equiv \int_{y_i}^\infty (y - y_i) dG(y).$$

It will prove useful to rewrite the markup-adjusted (residual) demand level $S^k$, defined by (2), as

$$S^k = \frac{\beta I^k}{\sigma} \left[M^k \Theta(y_0^k) + M^{k'} \left\{T \Theta(y_1^{k'}) + (T^\lambda - T) \Theta(y_2^{k'})\right\}\right]^{-1} \tag{20}$$

[5] For each country, there is the additional restriction that $\nu M^k \geq M^k \left[1 - G(y_1^k)\right]$. However, since the two countries are assumed to be of sufficiently similar size, this condition is satisfied if (16) holds.

where

$$\Theta(y_i) \equiv \int_{y_i}^{\infty} y dG(y) = \Phi(y_i) + y_i \left[1 - G(y_i)\right].$$

*Equilibrium.* Equilibrium in model II can now be formally defined as the collection of endogenous variables for each country $k$, $\left\{V^k(\cdot), W(\cdot), M^k, S^k, y_0^k, y_1^k, y_2^k\right\}_{k\in\{h,f\}}$, satisfying equations (11) to (20).

**Remark 2** *We have defined equilibrium* assuming *that each of the three modes of foreign market access (export, greenfield FDI, cross-border M&A) is chosen by some firms in equilibrium. It is straightforward to define equilibrium more generally. While* any *equilibrium has the property that there exist thresholds* $0 \leq y_0^k \leq y_1^k \leq y_2^k$ *such that a firm with immobile capability* $y^k$ *in country* $k$ *will be inactive if* $0 \leq y^k < y_0^k$*, engaged in cross-border M&A if* $y_0^k \leq y^k < y_1^k$*, engaged in exporting if* $y_1^k \leq y^k < y_2^k$*, and engaged in greenfield FDI if* $y^k \geq y_2^k$*, parameter values may be such that* $y_i^k = y_{i+1}^k$ *for* $i \in \{0, 1, 2\}$ *in equilibrium. It is straightforward to find sufficient conditions that ensure that each of the three modes of market access is chosen by some firms in equilibrium. For instance, there exist tresholds* $\underline{\nu}$ *and* $\overline{\nu}$*,* $0 < \underline{\nu} < \overline{\nu} < 1$*, such that if* $\nu \in (\underline{\nu}, \overline{\nu})$ *and* $F_N$ *(or* $T$*) is sufficiently small, then* $z_0^k < z_1^k < z_2^k$*.*

### 3.3 Discussion

In both models, different firms will choose a different mode of foreign market access. However, the two models differ in their predictions on the relationship between a firm's efficiency (as measured by its marginal cost of producing the intermediate input) and its equilibrium mode of foreign market access. In model I, the most efficient firms engage in cross-border M&A, less efficient firms engage in greenfield FDI, while the least efficient active firms export to the foreign country. In contrast, in model II, it is the least efficient active firms that engage in cross-border M&A, more efficient firms engage in exporting, and the most efficient firms in greenfield FDI. Below, we discuss the economics of the assignment of capabilities, and provide an intuition for the differences in the predictions of the two models.

To understand the role of mergers in our model, consider a social planner whose objective it is to assemble firms from the existing (post-entry) supplies of mobile and immobile capabilities in each country so as to maximize aggregate industry profits (taking as given firms' pricing decisions). The social planner faces a different problem in the two models as the distribution of capabilities is very different. In model I, the mobile capability $z$ is heterogeneous, and in each country the supply of these capabilities exceeds the supply of the viable homogeneous capability $y^k = 1$. In contrast, in model II, it is the immobile capability $y$ that is heterogeneous, and in each country the supply of all $y^k > 0$ is greater than the supply of the viable mobile capability $z = 1$.

If cross-border mergers were not feasible, the social planner would simply assign one unit of the scarce homogeneous capability to each of the best heterogeneous capability, and leave idle those heterogeneous capabilities that fall below a threshold level. If cross-border mergers are feasible, as we assume, the problem of assembling firms becomes considerably more interesting. The social planner can assemble two kinds of firms: (i) firms that produce the intermediate input in only one country by combining one viable mobile and immobile capability, and (ii) firms that produce the intermediate input in both countries by combining one viable mobile capability with one viable immobile capability from each country. By doing the latter, the planner allows this firm to avoid transport costs but forces it to incur additional fixed costs. Moreover, this also allows the planner to conserve scarce mobile capabilities, but it comes with two types of costs: (1) each $y^k$ will be able to serve only one market rather than two, and (2) by assigning two $y$'s to one $z$, fewer immobile capabilities are available for other use.

In both models, the combination of heterogeneous capabilities and transport costs create a "superstar" phenomenon. As pointed out by Rosen (1981), superstars should serve larger markets because their exceptional qualities can be spread over a larger number of units. Iceberg-type transport costs reduce the effective market size for firms that incur them. Since cross-border M&A is associated with lower transport costs than either exporting or greenfield FDI, the effective market size for a mobile capability that is involved in a cross-border merger is larger than that of a mobile capability that is involved in another mode of foreign market access. In contrast, the mobile capabilities involved in a cross-border merger only serve the local market, while those involved in exporting or greenfield FDI serve also the foreign market. In our two models, different types of capabilities have superstar qualities. In model I, the best mobile capabilities are the superstars, while in model II, it is the best immobile capabilities that are the superstars. Hence, in model I, the social planner wants to use the superstars (high $z$'s) for cross-border mergers, while in model II, the planner does not want to waste the superstars (high $y^k$'s) by only serving the local market as part of a cross-border merger. Related to this superstar phenomenon is the choice of firms between greenfield FDI and exporting. Both modes of foreign market access involve mobile and immobile capabilities in only one location, but the former involves lower transport costs and hence a larger effective market size. Consequently, in both models, more efficient firms (i.e., higher $z$'s in model I and higher $y^k$'s in model II) will engage in greenfield FDI than in exporting.

In both models, there is only one-sided heterogeneity in capabilities. Suppose instead both mobile and immobile capabilities were heterogeneous. From the above discussion, cross-border mergers should involve the best mobile capabilities and the worst immobile capabilities. However, complementarities between mobile and immobile capabilities (as assumed in our model) should imply positive assortative matching, i.e., the best immobile capabilities should be employed with the best mobile capabilities. Hence, if the best mobile and immobile capabilities were involved in cross-border M&A, the best immobile capabilities would wastefully serve only one market. Given this complex interaction of the countervailing effects, general analytical results for the case of two-sided heterogeneity are unavailable. This motivates our focus on the two polar cases of one-sided heterogeneity.

# 4 Comparative Statics

## 4.1 Country Size

What is the effect of country size on the equilibrium pattern of exports, greenfield FDI, and cross-border M&A? We address this question by first assuming that countries are initially identical, i.e., $I^h = I^f$, and then considering a small change in country sizes that maintains global income so that $dI^k = -dI^{k'} > 0$. The following lemma simplifies our discussion.

**Lemma 3** *Suppose the two countries are initially of the same size, i.e., $I^h = I^f$, and consider a small change in country sizes such that $dI^k = -dI^{k'}$. Then, the change in any endogenous variable u has the same absolute value in the two countries, but is of opposite sign: $du^k = -du^{k'}$.*

We now turn to the effects of changes in country size in model I.

**Proposition 4** *Consider model I. Suppose the two countries are initially of the same size, i.e., $I^h = I^f$, and consider a small increase in the size of country k (and a small decrease in the size of country $k' \neq k$) such that $dI^k = -dI^{k'} > 0$. Then,*

$$dS^k = -dS^{k'} > 0, \quad dM^k = -dM^{k'} > 0, \quad dV^k(1) = -dV^{k'}(1) < 0,$$

*and*

$$dW^k(z) = -dW^{k'}(z) \begin{cases} > 0 & \text{if } z \in (z_0^k, z_2^k), \\ = 0 & \text{otherwise}, \end{cases},$$

*where $z_0^k$ and $z_2^k$ are the (new) thresholds in the larger market. Furthermore,*

$$dz_0^k = -dz_0^{k'} < 0, \quad dz_1^k = -dz_1^{k'} > 0, \quad dz_2^k = -dz_2^{k'} > 0.$$

We now want to discuss the intuition for these results. Appealing to lemma 3, we focus on the larger country $k$. The direct effect of a redistribution of global income is to raise the markup-adjusted residual demand curve in country $k$. This raises the number of entrants, $M^k$. Consider now the merger market clearing condition for country $k$, (7),

$$M^k \left[\mu + H(z_0^k) - 1\right] = M^{k'} \left[1 - H(z_2^{k'})\right].$$

On the l.h.s. is the "net supply" of local capability $y^k = 1$ (after domestic mergers), while on the r.h.s. is the foreign demand for this capability. At the initial thresholds, there is now an excess supply of the immobile capability $y^k = 1$. This causes the market value of this capability to drop, $dV^k(1) < 0$. This implies that it is now more attractive for mobile capabilities to be used in the larger market: demand is higher, $dS^k > 0$, and immobile capabilities are cheaper, $dV^k(1) < 0$. Firms in the smaller country $k'$ will therefore integrate to a larger extent into country $k$, and so $dz_1^{k'} < 0$ and $dz_2^{k'} < 0$. For the same reason, the value of those mobile capabilities in country $k$ that are used for exporting or greenfield FDI is now larger, $dW^k(z) > 0$ for $z \in (z_0^k, z_2^k)$. Consequently, less efficient mobile capabilities will still be used in equilibrium, $dz_0^k < 0$. Since global market size remains unchanged, the value of those mobile capabilities that continue to be used for cross-border M&A does not change.

We now turn to the effects of changes in country size in model II.

**Proposition 5** *Consider model II. Suppose the two countries are initially of the same size, i.e., $I^h = I^f$, and consider a small increase in the size of country $k$ (and a small decrease in the size of country $k' \neq k$) such that $dI^k = -dI^{k'} > 0$. Then,*

$$dS^k = -dS^{k'} > 0, \quad dM^k = -dM^{k'} > 0, \quad dW(1) = 0,$$

*and there exists a unique cutoff $\widehat{y} \in (y_0^k, y_1^k]$ such that*

$$dV^k(y) = -dV^{k'}(y) \begin{cases} > 0 & \text{if } y > \widehat{y} \\ < 0 & \text{if } y \in (y_0^{k'}, \widehat{y}) \end{cases},$$

*where $y_i^k$ ($y_i^{k'}$)refers to a new threshold in market $k$ ($k'$). Furthermore,*

$$dy_0^k = -dy_0^{k'} > 0, \quad dy_1^k = -dy_1^{k'} < 0, \quad dy_2^k = -dy_2^{k'} > 0.$$

The direct effect of the redistribution of global income from country $k'$ to country $k$ is to raise the markup-adjusted residual demand level $S^k$ in country $k$, and to reduce it in country $k^{'}$. This direct effect has several immediate implications. First, it follows from equation (14) that $dy_2^k > 0$: firms switch from greenfield FDI to exporting since the incentive to avoid transport cost is lower in a smaller market. Another direct impact of the redistribution of global income is to alter the value of immobile capabilities in each country. As can be seen from equation (11), the increase in $S^k$ directly raises the value of all immobile capabilities $V^k(y)$ in country $k$. In contrast, the shadow value of viable mobile capabilities is unaffected by the redistribution of global income, which follows from the fact that the value of these capabilities must be the same in both countries. The increase in the value of immobile capabilities in country $k$ induces an increase in the number of entrants, $M^k$. The larger number of entrants supply more immobile capabilities, and so this depresses their value, and reduces each firm's residual demand. Does the increased number of entrants reduce the markup-adjusted demand level $S^k$ and the price schedule $V^k(y)$ to its initial values? The answer is no. If they were to return to their initial levels, the thresholds $y_i^k$ would be the same as before, but the number of firms in each country would be different. However, in this case, the merger market would not clear:

$$M^k \left[G(y_1^k) - G(y_0^k)\right] > M^{k'} \left[G(y_1^{k'}) - G(y_0^{k'})\right]$$

as $M^k > M^{k'}$and $y_i^k = y_i^{k'}$. Intuitively, there is an excess supply of small $y^k$'s, and so their market price must fall, and $dy_0^k > 0$. However, in expectation, the value of an entrant's draw of $y^k$ must remain unchanged, as can be seen from the free entry condition. It follows that the market value of large $y^k$'s must rise. Despite the larger number of entrants, the residual demand level $S^k$ must be larger, and so the incremental value of a slightly better $y^k$ increases: the price schedule $V^k(y)$ becomes steeper.

*General Discussion.* The most important difference in the predictions of the two models is the following: while model I predicts that weaker firms are able to survive in the larger market, the opposite is true in model II. The closed-economy models of Asplund and Nocke (2003) and Nocke (2003) predict that firms have to be more efficient to survive in larger markets, which is in line with the predictions of model II. However, their result is due to an endogenous increase in the intensity of price competition in larger markets. A common implication of both models I and II is that the fraction of entrants who engage in FDI (through either greenfield or cross-border mergers) is smaller in the larger country.

Most importantly, market size "matters" in both models because of the merger market. In the absence of the merger market, free entry would imply that the markup-adjusted residual demand level is the same in both countries, $S^k = S^{k'}$, and so the thresholds are the same as well. This would hold independently of any size difference; see, for instance, Helpman, Melitz, and Yeaple (2003). While the merger market is necessary in both models for market size to matter, model I requires an additional ingredient: the fixed costs $F_A$ and $F_N$ of managing production abroad. In contrast, in model II, market size would matter even in the absence of such a fixed cost. To see this, consider model I in the absence of the fixed costs $F_A$ and $F_N$. In this case, the origin of a mobile capability does not matter, and so its price has to be the same in both countries, $W^k(z) = W^{k'}(z)$. The free entry condition then guarantees that the price of the viable immobile capability equalizes in the two markets, $V^k(1) = V^{k'}(1)$. This, in turn, implies that the residual demand level and the thresholds are the same as well. The fraction of the mobile capabilities contributed by country $k$ to cross-border mergers is then equal to that country's share of global entrants. As should be clear from our discussion above, in model II, market size would matter even in the absence of $F_A$ and $F_N$: if all the thresholds were the same, the larger number of entrants would generate excess supply of immobile capabilities from the larger country.

## 4.2 Industry Characteristics

We now investigate how the composition of international commerce changes with industry characteristics, namely transport costs and the fixed cost of cross-border M&A. For simplicity, we assume that the two countries are identical, and so $I^h = I^f$.

**Transport Costs.** We begin by considering the effects of a change in transport costs (or tariffs) in model I.

**Proposition 6** *Consider model I. Suppose the two countries are of the same size, i.e., $I^h = I^f$, and consider a decrease in transport costs, i.e., $dT > 0$. Then, for each country $k \in \{h, f\}$,*

$$\begin{aligned} dS^k &< 0, \quad dz_0^k < 0, \quad dz_2^k > 0, \\ \text{and } dz_1^k &> 0 \text{ if } T \text{ is sufficiently large.} \end{aligned}$$

To understand this result, note first that a decrease in transport costs directly reduces the residual demand level $S^k$ as all firms that incur transport costs charge lower prices. Saving on transport costs by engaging in cross-border M&A is now relatively less attractive, and so $dz_2^k > 0$. As can be seen from the merger market clearing condition, equation (7), this fall in foreign demand for domestic immobile capabilities reduces the market price of these capabilities, which means that the opportunity cost of staying in the market is now lower, and so less efficient mobile capabilities will remain in the market: $dz_0^k < 0$. Hence, a lowering of transport costs allows less efficient firms to survive. (This effect may not be obvious since the fall in the residual demand level would tend to have the opposite effect.)

The reduction in transport costs has a direct and an indirect effect on $z_1^k$, the marginal mobile capability that has equal value in exporting and in greenfield FDI. The direct effect of lower transport costs reduces the transport costs associated with exporting by a larger fraction than those associated with greenfield FDI. On the other hand, however, a firm engaging in greenfield FDI sells a larger quantity in the foreign market than an exporter because it has to incur smaller transport costs. The sign of the direct effect depends on the level of $T$. If transportation costs are sufficiently small ($T$ is large), then the difference in the magnitude of sales between a firm engaging in greenfield FDI and a firm engaging in exporting is small, and so the net direct effect of lower transport costs is to make exporting relatively more attractive. The indirect effect of higher $T$ through $S^k$ on $z_1^k$ is always positive: the smaller demand level implies that the fixed cost of greenfield FDI has to be spread over fewer units, and so make greenfield relatively less attractive. Hence, if $T$ is sufficiently large, the net effect of lower transport costs is to raise $z_1^k$.

We now turn to the effects of changes in transport costs in model II.

**Proposition 7** *Consider model II. Suppose the two countries are of the same size, i.e., $I^h = I^f$, and consider a decrease in transport costs, i.e., $dT > 0$. Then, for each country $k \in \{h, f\}$,*

$$\begin{aligned} dS^k &< 0, \quad dy_0^k > 0, \quad dy_1^k < 0, \\ \text{and } dy_2^k &> 0 \text{ if } T \text{ is sufficiently large.} \end{aligned}$$

A decrease in transport costs makes exporting more attractive relative to cross-border M&A, and thus reduces the threshold $y_1^k$. It also reduces the residual demand level $S^k$ as competition becomes more intense. The threshold $y_0^k$ has to rise for two reasons. First, for the merger market for mobile capabilities to clear, as can be seen from equation (16): as the fraction of firms engaging in exports or greenfield FDI increase, the demand for mobile capabilities increases, and so their market value rises. Consequently, the opportunity cost of using the least efficient immobile capabilities increases. Second, the lower residual demand level $S^k$ implies that the benefit of using the least efficient immobile capabilities has fallen. Hence, in contrast to model I, lower transport costs implies that less efficient firms are not able to survive. The effect of lower transport costs on the marginal immobile capability $y_2^k$ that has equal value in exporting and in greenfield FDI is analogous to the effect on $z_1^k$ in model I.

**Tax on Cross-Border Mergers.** To better understand the role of cross-border mergers in our model, we ask how the within-industry composition of international commerce would change if a tax was imposed on cross-border mergers, which is equivalent to an increase in the fixed cost $F_N$ of managing the production of the intermediate input abroad. Such a tax might also reflect other costs of purchasing a firm abroad such as information costs (due, for example, to different accounting standards). We first consider model I.

**Proposition 8** *Consider model I. Suppose the two countries are of the same size, i.e., $I^h = I^f$, and consider a tax on cross-border mergers or an increase in the fixed cost of managing* *intermediate input production abroad, $F_N$. Then, for each country $k \in \{h, f\}$,*

$$dS^k > 0, \quad dz_0^k < 0, \quad dz_1^k < 0, \quad dz_2^k > 0.$$

The direct effect of a rise in the cost of cross-border mergers leads to a substitution away from cross-border M&A towards greenfield investment, i.e., an increase in the threshold $z_2^k$. This reduces the foreign demand for local immobile capabilities, and thus their market price. Hence, the opportunity cost of using an inefficient mobile capability is lower, and so $dz_0^k < 0$. This effect is reinforced since competition is less intense as fewer firms engage in cross-border M&A and fewer firms enter the market, and so $dS^k > 0$. The increase in the residual demand level makes greenfield FDI more attractive relative to exporting since the fixed cost $F_A$ can be spread over more units, and so $dz_1^k < 0$. Intriguingly, a "tax" on a component of FDI causes the fraction of entrants engaging in FDI (either through greenfield or cross-border M&A) to increase.

We now turn to the effects of a tax on cross-border mergers in model II.

**Proposition 9** *Consider model II. Suppose the two countries are of the same size, i.e., $I^h = I^f$, and consider a tax on cross-border mergers or an increase in the fixed cost of managing intermediate input production abroad, $F_N$. Then, for each country $k \in \{h, f\}$,*

$$dS^k > 0, \quad dy_0^k > 0, \quad dy_1^k < 0, \quad dy_2^k < 0.$$

As in model I, the tax on cross-border mergers makes competition more intense and therefore raises the markup-adjusted residual demand level $S^k$. This allows firms engaging in greenfield FDI to spread their fixed costs over more units, and so reduces the threshold $y_2^k$. Moreover, the tax makes cross-border mergers less attractive relative to exporting, which implies $dy_1^k < 0$. As the fraction of firms engaging in exports or greenfield FDI increases, the demand for mobile capabilities increases, which in turn raises their market value. Hence, the opportunity cost for a less efficient immobile capability to stay in the market increases, and hence $dy_0^k > 0$ for the merger market for mobile capabilities to clear; see equation (16). Perhaps surprisingly, the least efficient firms do not remain in the market, despite the increase in the residual demand level $S^k$.

# 5 Conclusion

tbw

# Appendix: Proofs

**Lemma 10** *Suppose the two countries are initially of the same size, i.e., $I^h = I^f$, and consider a small change in country sizes such that $dI^k = -dI^{k'}$. Then, the change in any endogenous variable $u$ has the same absolute value in the two countries, but is of opposite sign: $du^k = -du^{k'}$.*

**Proof of lemma 3.** The endogenous variable $u$ in country $k$ may be written as a function of the country sizes, $f(I^k, I^{k'})$, where the first argument refers to the own country size, and the second argument to the size of the other country. Assuming differentiability of $f$ (which can be verified to hold for our problem at hand), the endogenous change in the value of $u^k$ is given by

$$du^k = f_1(I^k, I^{k'})dI^k + f_2(I^k, I^{k'})dI^{k'},$$

where $f_i$ is the derivative of $f$ with respect to its $i$th argument. Similarly, the endogenous change in the value of $u^{k'}$ is equal to

$$du^{k'} = f_1(I^{k'}, I^k)dI^{k'} + f_2(I^{k'}, I^k)dI^k.$$

Since $I^k = I^{k'}$, we have $f_i(I^k, I^{k'}) = f_i(I^{k'}, I^k)$. Moreover, by assumption, $dI^k = -dI^{k'}$, and so $du^{k'}$ can be rewritten as

$$\begin{aligned} du^{k'} &= -f_1(I^k, I^{k'})dI^k - f_2(I^k, I^{k'})dI^{k'} \\ &= -du^k. \end{aligned}$$

■

**Proof of proposition 4.** Since the two countries are (initially) of the same size, the merger market clearing condition (7) implies that

$$\mu = 2 - H(z_0^k) - H(z_2^k). \tag{21}$$

Taking the logarithm of the merger market clearing condition,then forming the total derivative, and applying lemma 3, yields

$$\frac{dM^k}{M^k} = \frac{h(z_2^k)dz_2^k - h(z_0^k)dz_0^k}{2\left[1 - H(z_2^k)\right]}. \tag{22}$$

Taking the total derivative of the free entry condition (8), and inserting (21), we obtain

$$2\left[1 - H(z_2^k)\right] dV^k(1) + \Gamma dS^k = 0, \tag{23}$$

where

$$\Gamma \equiv (1 - T)\Psi(z_0^k) - (T^\lambda - T)\Psi(z_1^k) - (1 - T^\lambda)\Psi(z_2^k)$$

Observe that changes in the tresholds $z_i^k$ cancel out (i.e., $dz_i^k = 0$). This is due to the envelope theorem and the fact that the thresholds are efficient from the firms' point of view in that they maximize (expected) profits. Note that $\Gamma > 0$ since $\Psi(z_0^k) > \Psi(z_1^k) > \Psi(z_2^k)$. It follows that $V^k(1)$ and $dS^k$ move in opposite directions, i.e., $dV^k(1)dS^k < 0$ whenever $dS^k \neq 0$.

Taking the total derivatives of the threshold equations (4) to (6) and using lemma 3, yields

$$\begin{aligned} \frac{dz_0^k}{z_0^k} &= \frac{dV^k(1)}{V^k(1)} - \left(\frac{1-T}{1+T}\right)\frac{dS^k}{S^k}, \\ \frac{dz_1^k}{z_1^k} &= \frac{dS^k}{S^k}, \\ \frac{dz_2^k}{z_2^k} &= \frac{dS^k}{S^k} - \frac{dV^k(1)}{V^k(1) + F_N}. \end{aligned} \tag{24}$$

We thus obtain that $z_1^k$ and $z_2^k$ move in the same direction as demand level $S^k$, while $z_0^k$ moves in the opposite direction. That is, $dz_1^k dS^k > 0$, $dz_2^k dS^k > 0$, and $dz_0^k dS^k < 0$, provided $dS^k \neq 0$. From equation (22), it then follows that the mass of entrants $M^k$ and demand level $S^k$ move in the same direction, i.e., $dM^k dS^k > 0$.

Finally, taking the total derivative of equation (10), we obtain

$$\frac{dS^k}{S^k} + \frac{\frac{dM^k}{M^k}\Gamma + \left\{(1-T)\Psi'(z_0^k)dz_0^k - (T^\lambda - T)\Psi'(z_1^k)dz_1^k - (1-T^\lambda)\Psi'(z_2^k)dz_2^k\right\}}{(1+T)\Psi\left(z_0^k\right) + (T^\lambda - T)\Psi\left(z_1^k\right) + (1-T^\lambda)\Psi\left(z_2^k\right)} = \frac{dI^k}{I^k}.$$

Since $\Psi'(z_i) < 0$, the term in curly brackets has the same sign as $dM^k$ and $dS^k$. Hence, we must have $dS^k > 0$ because $dI^k > 0$ by assumption. The assertion on $W^k(z)$ follows immediately from equation (3), $dS^k = -dS^{k'} > 0$, and $dV^k(1) = -dV^{k'}(1) < 0$. ■

**Proof of proposition 5.** Taking the total derivative of the equation for $y_0^k$, (12) or, equivalently, (18), and applying lemma 3, we obtain $dW(1) = 0$. Next, taking the total derivative of the equation for $y_2^k$, (14), gives

$$\frac{dS^k}{S^k} = \frac{dy_2^k}{y_2^k}. \tag{25}$$

Hence, the threshold $y_2^k$ moves in the same direction as demand level $S^k$, i.e., $dy_2^k dS^k > 0$, provided $dS^k \neq 0$. Similarly, from the equation for $y_1^k$, (13), it follows that

$$dy_0^k + T dy_1^k = -\left[y_0^k - T y_1^k\right]\frac{dS^k}{S^k}, \tag{26}$$

where the term in brackets on the r.h.s. is positive since, with initially identical countries,

$$y_0^k - T y_1^k = \frac{F_N + F_A}{S^k}. \tag{27}$$

Consider now the free entry condition, equation (17). Taking the total derivative, and using (25) and (26), yields

$$\frac{dS^k}{S^k}\left\{B - \left[G(y_1^k) - G(y_0^k)\right]y_0^k\right\} = \left[G(y_1^k) - G(y_0^k)\right]dy_0^k, \tag{28}$$

where

$$B \equiv \int_{y_0^k}^{y_1^k} y dG(y) + (1-T)\int_{y_1^k}^{y_2^k} y dG(y) + \left(1 - T^\lambda\right)\int_{y_2^k}^{\infty} y dG(y).$$

Note that the term in curly brackets on the left-hand side of 28 is positive. It is then immediate that the threshold $y_0^k$ moves in the same direction as demand level $S^k$, i.e., $dy_0^k dS^k > 0$, assuming $dS^k \neq 0$. From (26), it follows that $y_1^k$ has to move in the opposite direction, i.e., $dy_1^k dS^k < 0$. Taking the total derivative of the merger market clearing condition (15), we obtain

$$\frac{dM^k}{M^k} = \frac{g(y_0^k)dy_0^k - g(y_1^k)dy_1^k}{G(y_1^k) - G(y_0^k)}. \tag{29}$$

Since $y_0^k$ moves in the same direction as $S^k$, while $y_1^k$ moves in the opposition direction, it follows that the mass of entrants, $M^k$, moves in the same direction as $S^k$, i.e., $dM^k dS^k > 0$.

It remains to show that demand level $S^k$ moves in the same direction as income (or country size) $I^k$. Totally differentiating (20), yields

$$\begin{aligned}\frac{\beta}{\sigma}dI^k &= \frac{\beta I^k}{\sigma}\frac{dS^k}{S^k} + S^k B dM^k - S^k M^k y_0^k g(y_0^k) dy_0^k \\ &\quad + S^k M^k T y_1^k g(y_1^k) dy_1^k + S^k M^k (T^\lambda - T) y_2^k g(y_2^k) dy_2^k, \end{aligned} \tag{30}$$

Substituting (29) into (30), and using (25), (26), and (28), yields

$$\begin{aligned}\frac{\beta}{\sigma}dI^k &= \left\{ \frac{dS^k}{S^k}\frac{\beta I^k}{\sigma} + S^k M^k \frac{g(y_1^k)}{T} y_0^k \left(y_0^k - T y_1^k\right) + S^k M^k (T^\lambda - T)\left(y_2^k\right)^2 g(y_2^k) \right. \\ &\quad \left. - S^k M^k g(y_1^k)\left(y_0^k - T y_1^k\right) \right\} + dy_0^k S^k M^k \left\{ \frac{g(y_0^k) + g(y_1^k)/T}{G(y_1^k) - G(y_0^k)} B \right. \\ &\quad \left. + \frac{g(y_1^k)}{T}\left(y_0^k - T y_1^k\right) - y_0^k g(y_0^k) - y_1^k g(y_1^k) \right\}.\end{aligned}$$

Collecting terms and using (27), this equation can be rewritten as

$$\begin{aligned}\frac{\beta}{\sigma}dI^k &= \frac{dS^k}{S^k}\left\{ \frac{\beta I^k}{\sigma} + S^k M^k \left[ (T^\lambda - T)\left(y_2^k\right)^2 g(y_2^k) + \frac{\left(y_0^k - T y_1^k\right)^2}{T} g(y_1^k) \right] \right\} \\ &\quad + \left\{ dy_0^k \frac{2 g(y_1^k)\left(F_N + F_A\right)}{S^k T} + \frac{g(y_0^k) + g(y_1^k)/T}{G(y_1^k) - G(y_0^k)} \left[ \int_{y_0^k}^{y_1^k} (y - y_0^k) dG(y) \right. \right. \\ &\quad \left. \left. + (1 - T)\int_{y_1^k}^{y_2^k} y dG(y) + \left(1 - T^\lambda\right)\int_{y_2^k}^{\infty} y dG(y) \right] \right\}.\end{aligned}$$

Since the curly brackets on the r.h.s. are positive, and $dy_0^k dS^k > 0$, it follows that demand level $S^k$ and income $I^k$ move in the same direction, i.e., $dS^k > 0$ since $dI^k > 0$ by assumption. ■

**Lemma 11** *Suppose the two countries are of the same size, i.e., $I^h = I^f$. Then, in model I, any change in exogenous variables (except $\mu$) causes the thresholds $z_0^k$ and $z_2^k$ to move in opposite directions. That is, $dz_0^k dz_2^k < 0$, provided $dz_0^k \neq 0$ or $dz_2^k \neq 0$.*

**Proof.** Since the two countries are identical, the merger market clearing condition (7) implies that

$$\mu = 2 - H(z_0^k) - H(z_2^k).$$

Taking the total derivative (and assuming $d\mu = 0$), we obtain

$$h(z_0^k) dz_0^k = -h(z_2^k) dz_2^k,$$

which establishes the result. ■

**Lemma 12** *Suppose the two countries are of the same size, i.e.,* $I^h = I^f$*. Then, in model II, any change in exogenous variables (except* $\nu$*) causes the thresholds* $y_0^k$ *and* $y_1^k$ *to move in opposite directions. That is,* $dy_0^k dy_1^k < 0$*, provided* $dy_0^k \neq 0$ *or* $dy_1^k \neq 0$*.*

**Proof.** Since the two countries are identical, the market clearing condition for mobile factors, (16), implies that

$$2(1-\nu) = G(y_0^k) + G(y_1^k).$$

The assertion follows immediately. ■

**Proof of proposition 6.** Imposing symmetry and taking the total derivative of the free entry condition (8), yields

$$\frac{dS^k}{S^k} = -\frac{\Psi(z_0^k) - \left(\lambda T^{\lambda-1} - 1\right)\Psi(z_1^k) - \lambda T^{\lambda-1}\Psi(z_2^k)}{(1+T)\Psi(z_0^k) + (T^\lambda - T)\Psi(z_1^k) + (1-T^\lambda)\Psi(z_2^k)} dT. \tag{31}$$

As in the proof of proposition 4, changes in the thresholds $z_i$ cancel out (due to the envelope theorem). Here, however, changes in the market price of working plants, $V^k(1)$, cancel out as well (if one takes the merger market clearing condition into account) because the two countries are identical. Since the term in front of $dT$ in equation (31) is negative, $S^k$ and $T$ move in opposite directions, and hence $dS^k < 0$.

Taking the total derivative of the equation for $z_1^k$ (see (5)), we obtain

$$\frac{dz_1^k}{z_1^k} = -\frac{dS^k}{S^k} - \frac{\lambda T^{\lambda-1} - 1}{T^\lambda - T} dT.$$

The first term on the r.h.s. is positive, while the second is positive as well if $\lambda < T^{1-\lambda}$. Hence, if $T$ is sufficiently large, then $dz_1^k > 0$. Using the expressions for $z_0^k$ and $z_2^k$ in (4) and (6), we can rewrite $z_2^k$ as

$$z_2^k = \frac{z_0^k(1+T)S^k + F_N}{(1-T^\lambda)S}.$$

Taking the total derivative and rearranging the resulting expression using (6), we obtain

$$dz_2^k = dz_0^k\left(\frac{1+T}{1-T^\lambda}\right) + dT\left(\frac{z_0^k + z_2^k}{1-T^\lambda}\right) - \frac{dS^k}{S^k}\left(\frac{T^\lambda(1+T)z_0^k + F_N}{(1-T^\lambda)^2}\right).$$

The second and third term on the r.h.s. are clearly positive. Hence, if $dz_0^k > 0$, then $dz_2^k > 0$. However, this contradicts lemma 11, which states that $z_0^k$ and $z_2^k$ move in opposite directions. Consequently, we must have $dz_0^k < 0$ and $dz_2^k > 0$. ■

**Proof of proposition 7.** Imposing symmetry, and totally differentiating the equation for threshold $y_0^k$, (12), we obtain

$$dW(1) = 2\left[y_0^k dS^k + S^k dy_0^k\right]. \tag{32}$$

Similarly, from the equation for $y_1^k$, (13), we derive

$$dT = \left( \frac{y_0^k - T y_1^k}{y_1^k} \right) \frac{dS^k}{S^k} + \frac{dy_0^k - T dy_1^k}{y_1^k}. \tag{33}$$

Taking the total derivative of (14), the equation for $y_2^k$, yields

$$\frac{dy_2^k}{y_2^k} = -\left\{ \frac{\lambda T^{\lambda-1} - 1}{T^\lambda - T} dT + \frac{dS^k}{S^k} \right\}. \tag{34}$$

Totally differentiating the free entry condition, (17), we get

$$\begin{aligned} & \nu dW(1) + dS^k \left\{ \Phi(y_0^k) + T\Phi(y_1^k) + (T^\lambda - T)\Phi(y_2^k) \right\} \\ & -S^k \left\{ \left[1 - G(y_0^k)\right] dy_0^k + T \left[1 - G(y_1^k)\right] dy_1^k + (T^\lambda - T) \left[1 - G(y_2^k)\right] dy_2^k \right\} \\ = \; & -S^k \left\{ \Phi(y_1^k) - \lambda \Phi(y_2^k) \right\} dT. \end{aligned} \tag{35}$$

From the merger market clearing condition (15), we can replace $\nu$ in (35) by $\nu = \left[2 - G(y_0^k) - G(y_1^k)\right]$. Moreover, using equations (32) to (34), we can rewrite (35) as

$$\frac{dS^k}{S^k} \left\{ \Theta(y_0^k) + T\Theta(y_1^k) + (T^\lambda - T)\Theta(y_2^k) \right\} = -\left\{ \Theta(y_1^k) + \left(\lambda T^{\lambda-1} - 1\right) \Theta(y_2^k) \right\} dT. \tag{36}$$

Clearly, the terms in curly brackets are positive. Hence, we have $dS^k < 0$, because $dT > 0$ by assumption. From (33) and lemma 12, and noting that $y_0^k > T y_1^k$, we obtain that $dy_0^k > 0$ and $dy_1^k < 0$. As to $dy_2^k$, observe that the second term in curly brackets in equation (34) is negative, while the first term is negative as well if $T^{1-\lambda} > \lambda$. Hence, if $T$ is sufficiently large, then $dy_2^k > 0$. ■

**Proof of proposition 8.** *Part (a).* Imposing symmetry and taking the total derivative of the free entry clearing condition (8) and using 8 to simplify the resulting expression, we obtain

$$dS^k = \frac{\left(1 - H(z_2^k)\right) F_N}{F_e + \left(1 - H(z_1^k)\right) F_A + \left(1 - H(z_2^k)\right) F_N} \frac{dF_N}{F_N}, \tag{37}$$

It follows immediately that $dF_N > 0$ implies $dS^k > 0$. Taking the total derivative of the equation for $z_1^k$ (see (5)), yields

$$\frac{dz_1^k}{z_1^k} = -\frac{dS^k}{S^k},$$

and hence $dz_1^k < 0$. Using the expressions for $z_0^k$ and $z_2^k$ in (4) and (6), we can rewrite $z_2^k$ as

$$z_2^k = \frac{z_0^k (1+T)}{(1 - T^\lambda)} + \frac{F_N}{(1 - T^\lambda) S^k}.$$

Taking the total derivative (and collecting terms), we obtain

$$dz_2^k = \frac{(1+T)}{(1-T^\lambda)} dz_0^k + \frac{F_N}{(1 - T^\lambda) S^k} \left[ \frac{dF_N}{F_N} - \frac{dS^k}{S^k} \right]. \tag{38}$$

By substituting 37 into this expression, it can be established that the second term on the right-hand side of 38 must be positive. From (38), it thus follows that if $dz_0^k > 0$, then $dz_2^k > 0$, contradicting lemma 11. Hence, we must have $dz_0^k < 0$ and $dz_2^k > 0$.

*Part (b).* From the threshold condition for $y_2^k$, (14), we obtain

$$\frac{dS^k}{S^k} = \frac{dy_2^k}{y_2^k}. \tag{39}$$

Hence, $y_2^k$ and $S^k$ move in opposite directions: $dy_2^k dS^k < 0$, provided $dS^k \neq 0$. Totally differentiation the threshold conditions for $y_0^k$, (12), and for $y_1^k$, (13), yields

$$2\left[y_0^k dS^k + S^k dy_0^k\right] = dW(1) + F_N \tag{40}$$

and

$$dF_N = S^k\left[dy_0^k - Tdy_1^k\right] + \left[y_0^k - Ty_1^k\right] dS^k, \tag{41}$$

respectively. Note also that, from the merger market clearing condition (15), we obtain

$$\nu = \frac{2 - G(y_0^k) - G(y_1^k)}{2}. \tag{42}$$

Taking the total derivative of the free entry condition (17), and using equations (39) to (42), yields

$$dS^k = \frac{G(y_1^k) - G(y_0^k)}{2\left\{\Theta(y_0^k) + T\Theta(y_1^k) + (T^\lambda - T)\,\Theta(y_2^k)\right\}} dF_N. \tag{43}$$

Hence, $dS^k > 0$ since $dF_N > 0$ by assumption. Inserting equation (43) into (41), we obtain

$$\begin{aligned} & dF_N\left\{1 - \frac{\left[y_0^k - Ty_1^k\right]\left[G(y_1^k) - G(y_0^k)\right]}{2\left\{\Theta(y_0^k) + T\Theta(y_1^k) + (T^\lambda - T)\,\Theta(y_2^k)\right\}}\right\} \\ = \;& S^k\left[dy_0^k - Tdy_1^k\right]. \end{aligned}$$

It is easy to verify that the expression in curly brackets is positive. Hence, from lemma 12, we must have $dy_0^k > 0$ and $dy_1^k < 0$. ■

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