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Cross-border mergers and acquisitions *vs.* greenfield foreign direct investment: The role of firm heterogeneity ☆

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Abstract

We develop a general equilibrium model with heterogeneous firms to address two sets of questions: (1) what are the characteristics of firms that choose the various modes of foreign market access (exporting, greenfield FDI, and cross-border M&A), and (2) how does the international organization of production vary across industries and country-pairs? We show that the answers to these questions depend on the nature of firm heterogeneity. Depending on whether firms differ in their mobile or immobile capabilities, cross-border mergers involve the most or the least efficient active firms. The comparative statics on industry and country characteristics display a similar dichotomy.

Keywords: Foreign direct investment; Mergers; Greenfield; Firm heterogeneity; Capabilities

JEL classification: F12; F23

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1. Introduction

In this paper, we develop a general equilibrium model of international trade and investment with heterogeneous firms. Firms can access foreign markets through exports, greenfield foreign direct investment, or cross-border merger and acquisition. In equilibrium, different firms choose different modes of foreign market access. The aim of this paper is to derive the "international organization of production": the mapping from firm type to mode of foreign market access. We show that the international organization of production is fundamentally different from one industry to another, depending crucially on the nature of firm heterogeneity.

In an increasingly globalized world, the decision of how best to serve foreign markets is becoming one of the key challenges facing firms. A firm that has decided to sell its product abroad has two distinct options of serving foreign markets: exporting or producing locally (foreign direct investment (FDI)). If the firm decides to produce locally, it can choose between building its own establishment (greenfield investment) or to acquire an existing firm (cross-border merger and acquisition (M&A)). While most of the empirical and theoretical literature has not distinguished between the two modes of FDI, greenfield and cross-border M&A, both are quantitatively important. According to UNCTAD (2000), the ratio of the value of global cross-border M&A to the value of global FDI ($865bn in 1999) is about 80%.

According to the "resource-based view of the firm" popular in the Management Strategy literature, heterogeneity across firms in their performance can ultimately be traced to the interplay between a firm's endowment of complementary "capabilities" or intangible assets (Wernerfelt, 1984). According to this view, mergers and acquisitions arise as firms can exploit complementarities among their capabilities. In an international context, the management strategy literature posits that some capabilities, such as marketing, distribution, and country-specific institutional competency are imperfectly mobile across countries (Anand and Delios, 2002). Cross-border M&A are then motivated by the desire of foreign firms to exploit complementarities between local firms' country-specific capabilities and the acquiring firms' "intangible technological advantages." That is, cross-border M&A are driven by the complementarities between internationally mobile and non-mobile capabilities. Caves (1996, p. 70) summarizes this motive as follows:

> The going concern is a working coalition. From the viewpoint of the foreign MNE, it possesses an operating local management familiar with the national market environment. The MNE that buys the local firm also buys access to a stock of valuable information.

A cross-border acquisition thus allows a firm to get costly access to the country-specific capabilities of the acquired firm, and the price of such an acquisition is governed by demand and supply of firms in the market for corporate control. In contrast, by engaging in greenfield FDI, a firm brings only its own capabilities to work abroad. Different firms will solve this trade-off differently.

One contribution of this paper is to introduce the "resource-based view of the firm" into a general equilibrium model of international trade and investment in which firms can choose between different modes of foreign market access (exporting *vs.* greenfield FDI *vs.* cross-border M&A). There are three key ingredients. First, there is heterogeneity in firms' capabilities. Second, these capabilities differ in their degree of international mobility. Third, firms can participate in the merger market so as to exploit complementarities between capabilities. We then use this framework to address two sets of questions:

(1) What are the characteristics of firms that choose these various modes of foreign market access, and

(2) How does the international organization of production – *i.e.*, the mapping from firm type to mode of foreign market access – vary across industries and country-pairs?

Our framework has important implications for our understanding of international trade and investment.

First, because we distinguish between mobile and non-mobile capabilities we introduce to the trade literature a new motive for firms to engage in FDI: to obtain non-mobile capabilities in other countries. We find that as capabilities become relatively less mobile internationally that cross-border M&A becomes the favored mode of entry into foreign markets. Given the relative importance of cross-border M&A in total FDI, our framework suggests that a key motive for FDI is to obtain non-mobile capabilities. To our knowledge, the empirical trade literature ignores the role of non-mobile capabilities in the trade-off between exports and FDI.

Second, we show that the source of firm heterogeneity is a critical determinant of the international organization of production. While firms have long been known to differ within industries in terms of their observed efficiency, the underlying source of this heterogeneity is likely to differ across industries. In industries where firms differ mainly in their mobile capabilities, the most efficient firms will engage in cross-border M&A, while in industries where firms differ mainly in their country-specific non-mobile capabilities, cross-border M&A will involve the least efficient active firms.[2]

This dichotomy has wide-ranging implications for empirical work. A small but fast-growing empirical literature seeks to understand the relationship between a firm's characteristics and its choice of mode of serving foreign markets. By and large, researchers impose a single mapping from firm characteristics to mode choice across industries and obtain mixed results. Our theory suggests the common procedure of pooling industries in regression analyses is inappropriate as the mapping from firm characteristics to mode choices differs qualitatively across industries in a systematic fashion.

Third, we show that the possibility of efficiency-enhancing mergers and acquisitions has wide-ranging implications for the productivity effects of changes in country and industry characteristics. In our model, foreign firms acquire local non-mobile capabilities by taking over local firms. Mergers and acquisitions thus have a direct effect on the nature of firms producing in a country and so influence aggregate industry efficiency. To the extent that changes in country and industry characteristics alter supply and demand in the market for corporate control, the effect of changes in these characteristics is mediated by the merger market. In models without cross-border M&A, the effect of country and industry variables on aggregate industry efficiency can be dramatically different. Our results are thus of interest to a growing empirical research into the effect of international trade and investment on aggregate industry efficiency.

1.1. Related literature

Our paper contributes to a growing literature that analyzes the endogenous selection of heterogeneous firms into modes of foreign market entry.[3] Within this literature, the paper that is closest in spirit to ours is Helpman et al. (2004) who consider only two modes of foreign market entry: exports and greenfield FDI. An important feature we share with Helpman et al. (HMY) and most of the trade literature on FDI is that we assume that, because of contracting problems, all

[2] Throughout the paper, we will say that a firm is more "efficient" than another if its domestic gross profits and sales are larger. The source of variation in gross profits and sales differs across industries.

[3] A key paper in this literature is Melitz (2003) who analyzes the decision of firms to enter foreign markets by becoming exporters. Other important papers include Bernard et al. (2003) and Antras and Helpman (2004).

activities have to be undertaken within the firm.[4] The key differences between our paper and that of HMY is that (i) we introduce the idea that not all types of capabilities are perfectly mobile internationally, and (ii) in our model, firms can participate in the merger market so as to exploit complementarities in their capabilities. By considering both mobile and non-mobile capabilities, our framework (1) gives rise to cross-border M&A, and (2) yields different predictions on the composition of international commerce. In HMY, firms that engage in FDI are the most efficient firms within an industry. In contrast, we find that firms conducting FDI via cross-border M&A are the least efficient active firms when the source of firm heterogeneity is due to non-mobile capabilities. We also find that the merger market clearing condition, not present in HMY, has important implications for the effect of country and industry characteristics on the distribution of firm efficiencies.

Our paper also contributes to the industrial organization literature on endogenous horizontal 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 Braguinsky (2004) that also takes a resource-based view of the firm. 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; Raff et al., 2005).[5]

1.2. Outline

The plan of the paper is as follows. In the next section, we describe in detail our theoretical framework. Then, in Section 3, we turn to the equilibrium analysis. We derive the international organization of production and show how it depends on the source of firm heterogeneity. In Section 4, we investigate the effects of country and industry characteristics on the international organization of production and the distribution of firm efficiencies. In Section 5, we discuss the empirical implications of our model. We conclude in Section 6.

2. The model

We consider a model of international trade and investment with two identical countries, 1 and 2, indexed by k (and sometimes l). The aggregate income level in each country is denoted by Y. Labor is the only factor of production and, since countries are identical, the price of labor in each country is normalized to 1.

2.1. Preferences

The representative consumer has two-tier preferences: Cobb–Douglas preferences over the two types of differentiated goods, M and N, and CES preferences over varieties of each differentiated good. She spends a fraction β_i of her income on the differentiated good industry

[4] While there is a long tradition of assuming that contracting problems require firms to own and operate all production activities, there is a growing literature that endogenizes the integration decision of firms. See for instance, Grossman and Helpman (2004), and Antras and Helpman (2004).

[5] 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.

$i \in \{M, N\}$. Her sub-utility over the varieties of the differentiated good $i \in \{M, N\}$ can be written as

$$X_i = \left[\int_{\omega \in \Omega_i} q(\omega)^{1-\rho_i} x(\omega)^{\rho_i} d\omega\right]^{\frac{1}{\rho_i}}, \rho_i = \frac{\sigma_i - 1}{\sigma_i}, \sigma_i > 1, \tag{1}$$

where $x(\omega)$ and $q(\omega)$ are the level of consumption and the perceived quality of variety ω, respectively, and σ_i the elasticity of substitution across varieties.

2.2. Firms

There is a continuum of (atomless) firms that differ in their capabilities. Some capabilities – such as technology or organizational capability – are likely to travel well across borders, while other capabilities – such as knowledge of local market conditions or local tastes and relationships with local suppliers or buyers – are (by their very nature) likely to travel less well from one country to another. To capture this idea, we distinguish between two types of capabilities: a "mobile" capability and a country-specific "non-mobile" capability.

The efficiency of a firm's production technology is assumed to be mobile internationally in the sense that the country of origin does not matter. There is an inverse relationship between a firm's *mobile* capability $\tilde{m}$ and a firm's marginal cost $c(\tilde{m})$:

$$c(\tilde{m}) = \begin{cases} \frac{1}{\tilde{m}} & \text{if } \tilde{m} > 0, \\ \infty & \text{otherwise.} \end{cases} \tag{2}$$

In contrast to technology, "marketing expertise" is assumed not to travel well across borders, and so we refer to it as a *non-mobile* capability. A defining feature of a non-mobile capability is that its country of "origin" and its country of "usage" matter in the sense that a non-mobile capability is more effective in its country of origin than abroad. Firm's differ in the quality of their marketing expertise, and the better the marketing expertise, the higher is the perceived quality of the good. If the firm uses its non-mobile capability originating in country $k \in \{1,2\}$, n^k, for serving the same country k, then its perceived quality in that country is $q^k = n^k$. But if it uses this capability to serve the other country $l \neq k$, then its perceived quality in country l is only $q^l = \delta_i n^k$, where $\delta_i \in (0,1)$. The parameter δ_i thus captures the disadvantage of using a non-mobile capability from a different country. Indeed, there is recent empirical evidence suggesting that domestic firms have an advantage over foreign firms in marketing activities in their own country; see Maurin et al. (2002).[6]

Both mobile and non-mobile capabilities are industry-specific and can only be used by one firm at any time. Following HMY and most of the trade literature on FDI, we assume that contracting problems in market transactions are severe, and so production and marketing have to be undertaken within the firm. A firm owning a collection of capabilities can use no more than

[6] We have chosen a particular route in modeling non-mobile capabilities. In a previous version of this paper, we took a different route in assuming that there are two stages of production, (i) the production of an intermediate input and (ii) assembly. Only (i) was assumed to require scarce capabilities. In contrast to the current set-up, however, non-mobile capabilities were completely country-specific. Consequently, greenfield FDI was restricted to assembly abroad. However, almost all of the results of the two set-ups are identical.

one capability of each type (non-mobile capability for each country, and mobile capability). Therefore, a firm can be defined by its ownership of its best mobile and non-mobile capabilities.

In addition to the limited mobility of marketing expertise, there are other frictions associated with international borders. First, there is a fixed coordination cost $F_{c,i}$ associated with managing production in country k while using a non-mobile capability originating from country $l \neq k$ to serve country k. This coordination cost need *not* be incurred if (i) production takes place only in country k and the firm uses a country-k non-mobile capability, and (ii) production takes place in both countries and the firm uses a non-mobile capability from each country. Second, iceberg-type transportation costs have to be incurred for shipping output across borders: $\tau_i > 1$ units need to be shipped for one unit to arrive in the foreign country. The existence of these transportation costs (or tariffs) makes the cost of serving a market sensitive to the location of production. If the good is produced in country k and then shipped to country $l \neq k$, the marginal cost of serving country l is $\tau_i c(\tilde{m})$.

For notational convenience, we will henceforth work with the following transforms of $\tilde{m}$ and τ_i:

$$m \equiv \widetilde{m}^{\sigma_i - 1} \text{ and } T_i \equiv \tau_i^{-(\sigma_i - 1)}. \tag{3}$$

The benefit of these transformations is that a firm's profit is linear in the redefined variables. Note that $T_i < 1$ is inversely related to τ_i, while m is positively related to $\tilde{m}$.

2.3. Entry

There is a continuum of atomless and *ex ante* identical potential entrants, each of which is endowed with the know how to produce a unique variety. Entrants can enter only in their own country. If an entrant decides not to enter, it obtains a payoff of zero. If it decides to enter its home market, the entrant has to pay an (irrecoverable) entry fee $F_{e,i}$. Then, the entrant receives a random draw of two types of capabilities: a "mobile" capability m, drawn from distribution function H_i, and a "non-mobile" capability, specific to the firm's home country k, n^k, drawn from distribution function G_i. An entrant in country k does not receive a non-mobile capability specific to the other country, *i.e.*, $n^l = 0$ for $l \neq k$. This captures in a tractable manner the idea that firms have an advantage in acquiring capabilities specific to their own home country. Henceforth, we will refer to (m, n) as the "type" of an entrant, where the value of n refers to the entrant's non-mobile capability in its home country.

2.4. Mergers and acquisitions market

There exists a perfectly competitive market for corporate control where entrants can be bought and sold. Let $V_i(m, n)$ denote the endogenous stock price of an entrant with mobile capability m and non-mobile capability n in industry i. (Since countries are identical, the stock prices do not depend on the entrant's country of origin.) That is, an entrant of type (m, n) can decide to sell itself at the stock price $V_i(m, n)$. Alternatively, the entrant can decide to acquire another entrant of type (m', n') from the same country ("domestic acquisition") or an entrant of type (m'', n'') from the other country ("cross-border acquisition"), or both. After two or more entrants have merged, the merged firm will own multiple mobile and non-mobile capabilities, but will use only the best mobile capability and the best non-mobile capability to serve each country (which means that either the firm uses a non-mobile capability from country k to serve both markets, or else it uses a non-mobile capability from country 1 to serve country 1, and a non-mobile capability from country 2 to serve country 2). It is worth emphasizing that 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.

Given that the merged firm will use only its best mobile capability, it is natural to think of the entrant with the best m amongst the merging entrants to acquire the other entrant(s), and to think of the other entrant(s) as the acquisition target(s). We will therefore associate the country of origin of the acquirer with the "home" country of the merged firm.

2.5. Firms and the post-merger location of production

As we will show in the next section, all firms serve their home market entirely from local production, but they differ in the way they serve the foreign market. If a firm locates production only in its home country, it exports its good to the foreign market, incurring iceberg-type transport costs. If a firm chooses to serve the foreign market by locating production abroad (FDI), it must choose between greenfield FDI and cross-border M&A. The crucial distinction between these two modes of FDI is that a firm engaging in the former does not acquire a non-mobile capability specific to the foreign country by merging with a foreign firm.

2.6. Product market competition

Since there is a continuum of atomless 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.

2.7. Timing

The timing of the model may be summarized as follows.

Stage 1 In each country, potential entrants decide whether or not to enter the market.
Stage 2 Entrants can participate in the merger market as buyers or sellers.
Stage 3 Firms decide where to locate production in order to most profitably serve both countries.
Stage 4 Firms compete in prices (or quantities) and receive profits.

Note that we refer to players as "potential entrants" at stage 1, "entrants" at stage 2, and "firms" at stages 3 and 4. The distinction between "entrants" and "firms" is useful as entrants may be acquired (or acquire other entrants) at stage 2.

2.8. Equilibrium

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

3. The international organization of production

In this section, we turn to the equilibrium analysis of our model and determine the equilibrium pattern of export, greenfield FDI, and international mergers. We derive firms' payoffs as a function of their capabilities and their mode of foreign market access. We then turn to the equilibrium analysis in each of the two industries. First, we will consider industry M, where firms differ in their mobile capabilities. Then, we will analyze industry N, where firms differ in their non-mobile capabilities.

We begin by deriving the gross profits of firms at the fourth stage. Solving the representative consumer's utility maximization problem, we obtain the residual demand for any variety of good i in country k:

$$x^k(\omega) = \beta_i Y (P_i^k)^{\sigma_i - 1} q^k(\omega) p^k(\omega)^{-\sigma_i},$$

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

$$P_i^k = \left[\int_{\omega \in \Omega_i} q^k(\omega) p^k(\omega)^{1-\sigma_i} d\omega \right]^{\frac{1}{1-\sigma_i}}$$

the aggregate price index for good i in country k. Since countries are symmetric, the prices indices in the two countries are the same: $P_i^k = P_i$ for $k = 1, 2$.

Let $\hat{c}_i^k(\omega)$ denote the marginal cost of *selling* variety ω 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 $p^k(\omega) = \hat{c}_i^k(\omega)/\rho_i$. Hence, the gross profit of a firm selling variety ω in country k is given by

$$S_i q^k(\omega) (\hat{c}_i^k(\omega))^{1-\sigma_i} \tag{4}$$

where the markup-adjusted residual demand level S_i is given by

$$S_i = \frac{\beta_i Y}{\sigma_i (\rho_i P_i)^{1-\sigma_i}}. \tag{5}$$

The firm's gross profit in country k, Eq. (4), depends upon: (i) the firm's mobile capability m, (ii) the firm's perceived quality in country k (which, in turn, depends upon the non-mobile capability used for serving country k, and the country of origin of that non-mobile capability), and (iii) the location of production for serving country k. Specifically, consider a firm with mobile capability m and non-mobile capabilities n^1 and n^2 from countries 1 and 2, respectively. The gross profit that this firm generates from sales in country k is given by

$S_i T_i \delta_i n^l m$ if production is in $l \neq k$, using a non-mobile capability from $l \neq k$,
$S_i \delta_i n^l m$ if production is in k, using a non-mobile capability from $l \neq k$,
$S_i n^k m$ if production is in k, using a non-mobile capability from k,

where $T_i = \tau_i^{1-\sigma_i} < 1$.

We now turn to the third stage, where firms decide where to locate production. We define the post-merger type of a firm as (m, n^1, n^2), where m is the firm's best mobile capability, and n^k the firm's best non-mobile capability specific to country k.[7] (Recall that if the firm was not the result of a cross-border merger, it does not own a viable non-mobile capability specific to the foreign country l, *i.e.*, $n^l = 0$.) If a firm uses a non-mobile capability only from the country where its best non-mobile capability is located, then it can serve the other country either through exporting, resulting in a profit of $(1 + T\delta) Sm \max\{n^1, n^2\}$, or through greenfield FDI, resulting in a profit of

[7] Note that a firm's (post-merger) type is denoted by a triplet while an entrant's (pre-merger) type is denoted by a tuple.

$(1+\delta)Sm\max\{n^1, n^2\}-F_c$. If a firm uses a non-mobile capability from each country (which is relevant only if the firm is the result of a cross-border merger), its profit is $Sm(n^1+n^2)$.

An immediate observation is the following. Let $\theta\equiv m\max\{n^1, n^2\}$. If firms were to use a non-mobile capability only from their home country, then firms with a sufficiently high value of θ would serve the foreign market through greenfield, while firms with a low value of θ would opt for exporting. This is essentially the point made by HMY. But HMY neglect that firms do have the option of acquiring foreign firms and their non-mobile capabilities, and indeed most of FDI between developed countries is in the form of mergers and acquisitions. Since we allow for mergers and acquisitions in our model, we will be able to provide a more comprehensive and interesting analysis of the international organization of production.

Consider now the second stage, where entrants can participate as buyers or sellers on the merger market. At this stage, an entrant of type (m, n) may decide to sell itself at the stock price $V_i(m,n)$, or it may decide to acquire another entrant of type (m',n') in country k at price $V_i(m',n')$. From the profits derived above, it follows that it will never be optimal to acquire more than one entrant per country. Since countries are identical we adopt the convention that an entrant acquires a foreign target with the intention to serve the foreign market only, *i.e.*, the acquirer's home market will always be served by domestic production (through the non-mobile capability with which the acquirer is endowed or else with the non-mobile capability of an acquisition target from the home country).

We are now in the position to give a first and partial analysis of the international organization of production from the view point of a potential acquirer. Consider an entrant of type (m, n) that, in equilibrium, will use both of its capabilities. If this entrant decides not to acquire a foreign entrant, it will serve the foreign market through either exports or greenfield, and its resulting profit will be

$$\max\{(1+T\delta)Smn, (1+\delta)Smn-F_c\}. \tag{6}$$

If, on the other hand, it decides to acquire a foreign entrant of type (m', n') so as to get access to a non-mobile capability specific to the other country, its resulting profit will be

$$Sm(n+n')-V_i(m',n'), \tag{7}$$

where $V_i(m', n')$ is the stock price of the foreign acquisition target. But the foreign acquisition target must be optimally chosen by the acquirer. Since the acquirer will not use the mobile capability of its target, we must have $V_i(m', n')=V_i(0, n')$ as otherwise if $V_i(m', n')>V_i(0, n')$, the acquirer could increase its profit by acquiring an entrant of type $(0, n')$. Further, the non-mobile capability of the target must satisfy $n'=\arg\max_{n''}\{Sm(n+n'')-V_i(0, n'')\}$. Note that the solution n' is independent of n but not independent of m. It should be emphasized that a crucial element of the analysis is still missing: entrants must be willing to be acquired at the stock price schedule $V_i(m', n')$.[8]

Consider now two polar cases of firm heterogeneity. First, suppose there is heterogeneity in m but not in n. Then, an entrant will choose to engage in cross-border M&A if its mobile capability m is sufficiently large. To see this, note that the profit from cross-border M&A, given by Eq. (7), increases at a faster rate with m than the profit of the best alternative, given by Eq. (6). Second, suppose there is heterogeneity in n but not in m. Then, an entrant will choose not to engage in cross-border M&A if its non-mobile capability n is sufficiently large. To see this, note that the

[8] The endogenous price schedule $V_i(m, n)$ for entrants on the merger market determines how the joint profits of a merged firm are split between the merging entrants, and this split depends *inter alia* on alternative mergers.

profit from cross-border M&A, given by Eq. (7), increases at a slower rate with n than the profit of the best alternative, given by Eq. (6). This contrast arises because an increase in the mobile capability m, raises the gross profit in both countries, while an increase in the non-mobile capability n raises the profit only in one country if the entrant is engaging in cross-border M&A. Hence, the source of firm heterogeneity is a crucial determinant of the international organization of production.

At the first stage, free entry of *ex ante* identical entrants implies that the expected value of a new entrant is equal to zero:

$$\int_0^{\infty}\int_0^{\infty} V_i(m,n)dH_i(m)dG_i(n) - F_{e,i} = 0. \tag{8}$$

In the real world, industries are likely to differ in the underlying source of heterogeneity between firms: in some industries, most of the firm heterogeneity may be in firms' mobile capabilities, while in other industries, most of the heterogeneity may be in firms' non-mobile capabilities. A key objective of our paper is to understand how the source of firm heterogeneity affects equilibrium at the second stage, and therefore the international organization of production. To this end, we assume that there are two industries, M and N, in which the underlying source of heterogeneity is in firms' mobile and non-mobile capabilities, respectively. Our discussion above suggests that the international organization of production should be very different in these two industries. Below, we will derive the general equilibrium and show that its properties depend crucially on the source of firm heterogeneity. We will proceed by analyzing industries M and N separately. For notational convenience, we henceforth drop the industry subscript.

3.1. Industry M

In this subsection, we consider industry M. In this industry, an entrant in country k gets a random draw of its mobile capability m from a continuous distribution function H with support $[0,\infty)$. In contrast, the distribution function G of its (country-k specific) non-mobile capability n^k is a step function: $n^k=0$ with probability $1-\mu$, and $n^k=1$ with the remaining probability μ. A firm's post-merger type can therefore take one of three forms: $(m, 1, 0)$, $(m, 0, 1)$, and $(m, 1, 1)$, where $m\in[0, \infty)$.

A firm of type $(m, 0, 1)$ or $(m, 1, 0)$ will serve the other (foreign) market through either exporting or greenfield. The associated profits are

$$\pi_x(m) = (1 + T\delta)Sm$$

and

$$\pi_g(m) = (1 + \delta)Sm - F_c.$$

A firm of type $(m, 1, 1)$ must have been the product of a cross-border merger and acquisition. Such a firm serves each market through local production, resulting in a profit of

$$\pi_a(m) = 2Sm.$$

Consider now an entrant of type $(m, 1)$ at stage 2. Suppose first that this entrant does not participate in the merger market. In this case, it will serve the foreign market through either exporting or greenfield, resulting in profits of $\pi_x(m)$ or $\pi_g(m)$, respectively. Suppose now that this entrant participates in the merger market. If this entrant's mobile capability will not be used by the merged firm, the entrant's stock price must be independent of m, and equal $V(0,1)$. (Given our convention that the acquirer is associated with the best m amongst the merging entrants, this case corresponds to the entrant selling itself on the merger market.) If this entrant's mobile capability will be used by the merged firm (*i.e.*, if it is the acquirer), then it must be that the merger involved one foreign entrant with a viable non-mobile capability whose mobile capability is not used. Hence, the entrant's payoff must be $\pi_a(m)-V(0,1)$ where $\pi_a(m)$ is the joint profit of the merged firm and $V(0,1)$ is the stock price of the foreign entrant. Hence, the stage-2 stock price of the entrant of type $(m,1)$ can be written as

$$V(m,1)=\max\{V(0,1),\pi_x(m),\pi_g(m),\pi_a(m)-V(0,1)\}. \tag{9}$$

We can partition the set of entrants of type $(m,1)$ into four subsets, Δ_0, Δ_x, Δ_g, and Δ_a. If $m\in\Delta_0$, the entrant sells itself on the merger market. If $m\in\Delta_x$, the entrant does not participate in the merger market, and serves the foreign country through exports. If $m\in\Delta_g$, the entrant does not participate in the merger market, and serves the foreign country through greenfield FDI. Finally, if $m\in\Delta_a$, the entrant acquires a foreign target with a viable non-mobile capability, and subsequently serves both markets through local production. From Eq. (9), the partial derivative of the stock price schedule $V(m,1)$ with respect to m is therefore given by

$$\frac{\partial V(m,1)}{\partial m}=\begin{cases} 0 & \text{if } m\in\Delta_0,\\ \pi_x'(m)=(1+T\delta)S & \text{if } m\in\Delta_x,\\ \pi_g'(m)=(1+\delta)S & \text{if } m\in\Delta_g,\\ \pi_a'(m)=2S & \text{if } m\in\Delta_a.\end{cases}$$

Since $0<\pi_x'(m)<\pi_g'(m)<\pi_a'(m)$, we obtain the following result.

Proposition 1. *There exist thresholds $0\le m_0\le m_1\le m_2$ such that $(0, m_0)$ is the interior of Δ_0, (m_0, m_1) is the interior of Δ_x, (m_1, m_2) is the interior of Δ_g, and (m_2,∞) is the interior of Δ_a.*

We henceforth assume that parameters are such that all four intervals, Δ_0, Δ_x, Δ_g, and Δ_a, are non-empty, *i.e.*, $0<m_0<m_1<m_2$. (It can be shown that such parameters do exist.) The thresholds can then be written as

$$m_0=\frac{V(0,1)}{S(1+T\delta)}, \tag{10}$$

$$m_1=\frac{F_c}{S\delta(1-T)}, \tag{11}$$

and

$$m_2=\frac{V(0,1)-F_c}{S(1-\delta)}. \tag{12}$$

Consider now an entrant of type $(m, 0)$. Given our convention that the entrant with the highest m amongst merging entrants is the acquirer, and the other merging entrant(s) the target(s), an entrant $(m, 0)$ cannot make a positive profit by selling itself on the merger market. It may, however, decide to exit and obtain zero profit. Alternatively, the entrant may participate in the merger market as an acquirer. First, it may decide to buy a domestic target with a viable non-mobile capability (specific to the entrant's home country) at stock price $V(0, 1)$. Subsequently, the firm can choose how best to serve the foreign market, either through exporting or greenfield. Second, it may decide to buy a domestic and a foreign target, each with a viable non-mobile capability specific to the target's home country. In this case, the firm will subsequently serve both countries through local production. Hence, the entrant's value is given by

$$V(m,0) = \max\{0, \pi_x(m) - V(0,1), \pi_g(m) - V(0,1), \pi_a(m) - 2V(0,1)\},$$

which can be re-written as

$$V(m,0) = \max\{0, V(m,1) - V(0,1)\}.$$

Since

$$\frac{\partial V(m,0)}{\partial m} = \frac{\partial V(m,1)}{\partial m} \text{ for all } m,$$

it follows that if $m \in \Delta_0$, then the entrant of type $(m,0)$ will exit. If $m \in \Delta_x$, the entrant will acquire a domestic target and subsequently export. If $m \in \Delta_g$, the entrant will acquire a domestic target and subsequently engage in greenfield. Finally, if $m \in \Delta_a$, the entrant will acquire both a domestic and foreign target.

Fig. 1 illustrates the international organization of production. The entrants with the best mobile capabilities acquire foreign targets, while the entrants with the worst capabilities either exit (if they are not endowed with a viable mobile capability) or else become acquisition targets. Moreover, entrants engaging in greenfield FDI have better mobile capabilities than entrants engaging in exporting.

For the merger market to clear, the mass of acquisition targets must be equal to the mass of entrants that the acquirers wish to take over. In each country, there is a mass $\mu EH(m_0)$ of acquisition targets. There are two groups of acquirers. Domestic acquirers are all domestic entrants

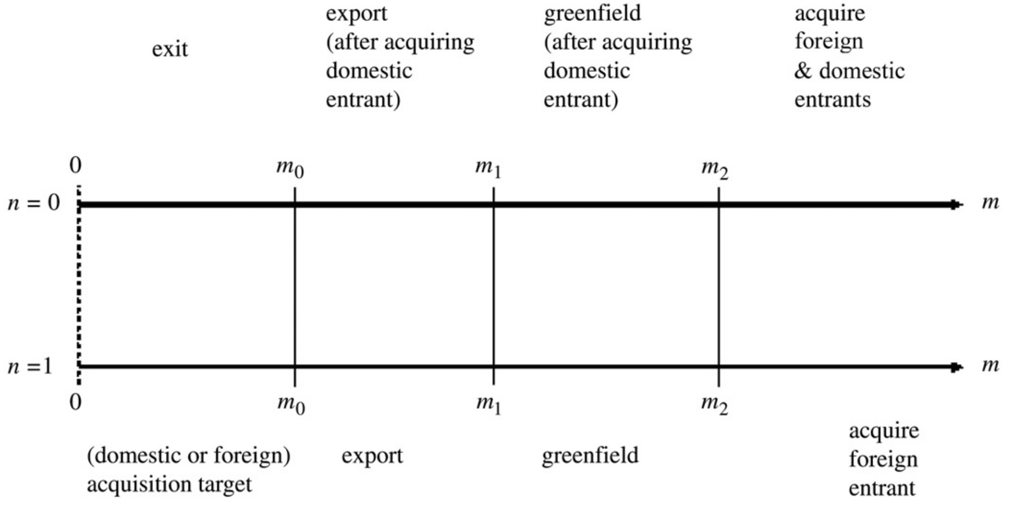

Fig. 1. The international organization of production in industry *M*.

of type $(m,0)$ with $m > m_0$, of which there is a mass $(1-\mu)E[1-H(m_0)]$. Foreign acquirers are all foreign entrants of types $(m, 0)$ or $(m, 1)$ with $m > m_2$, of which there is a mass $E[1-H(m_2)]$. The merger-market clearing condition is thus given by

$$\mu EH(m_0) = (1-\mu)E[1-H(m_0)] + E[1-H(m_2)],$$

which simplifies to

$$H(m_0) + H(m_2) = 2-\mu. \tag{13}$$

3.2. Industry N

In this subsection, we consider industry N. In this industry, an entrant in country k gets a random draw of its non-mobile capability n^k (specific to its home country k) from a continuous distribution function G with support $[0, \infty)$. In contrast, the distribution function H of its mobile capability m is a step function: $m=0$ with probability $1-v$, and $m=1$ with the remaining probability v. It is therefore natural to divide the population of entrants into two pools: (i) entrants of type $(1,n)$, *i.e.*, those with a viable mobile capability $m=1$, and (ii) entrants of type $(0,n)$, *i.e.*, those with a non-viable mobile capability $m=0$.

We first derive the stock price $V(0,n)$ of an entrant of type $(0,n)$. Note that such an entrant is either an acquisition target (by our convention) as it does not own a viable mobile capability, or else it exits. Let $\pi_i(n)$ denote the gross profit that a firm can make from using non-mobile capability n from country k in usage $i \in \{a,g,x\}$, where x means that the firm produces domestically and serves the foreign market through exports, g means that the firm produces domestically and serves the foreign market through greenfield, while a means that the firm produces domestically only for the domestic market (since it owns a non-mobile capability in the other country). Hence,

$$\pi_x(n) = (1 + T\delta)Sn,$$

$$\pi_g(n) = (1 + \delta)Sn,$$

and

$$\pi_a(n) = Sn.$$

The profit (net of the acquisition price) that an acquirer of target $(0,n)$ can make in usage i can be written as

$$\pi_i(n) - V(0, n).$$

We can partition the set of entrants of type $(0,n)$ into four subsets. If $n \in \Delta_0$, then the entrant will exit. If $n \in \Delta_a$, the entrant will be acquired for serving the domestic market only. If $n \in \Delta_x$, the entrant will be acquired for serving the domestic market and for serving the foreign market through exports. If $n \in \Delta_g$, the entrant will be acquired for serving the domestic market and for serving the foreign market through greenfield. No arbitrage implies that an acquirer has to be indifferent between all targets in Δ_i, $i \in \{a,m,g\}$, *i.e.*, $\pi_i(n) - V(0,n)$ is constant on Δ_i. Since $\pi_i(n) - V(0,n)$ is constant on Δ_i, $i \in \{a,m,g\}$, we must have $\pi_i'(n) = \partial V(0,n)/\partial n$ for all $n \in \Delta_i$. Hence, the market price schedule $V(0,n)$ is piece-wise linear:

$$\frac{\partial V(0,n)}{\partial n} = \begin{cases} 0 & \text{if } n \in \Delta_0, \\ \pi_a'(n) = S & \text{if } n \in \Delta_a, \\ \pi_x'(n) = (1+T\delta)S & \text{if } n \in \Delta_x, \\ \pi_g'(n) = (1+\delta)S & \text{if } n \in \Delta_g. \end{cases}$$

No arbitrage also implies that $V(0,n)$ is continuous in n. Moreover, $V(0,n)$ has to be (weakly) convex. To see this, suppose otherwise that there exists a $\tilde{n} \equiv \sup \Delta_i$ such that $\lim_{n\uparrow\tilde{n}} \partial V(0,\tilde{n})/\partial n > \lim_{n\downarrow\tilde{n}} \partial V(0,\tilde{n})/\partial n$. But this cannot be an equilibrium: rather than using non-mobile capability $\tilde{n}$ in usage i, the firm could do better by using non-mobile capability $\tilde{n}+\varepsilon$ in the same usage since, for n slightly larger than $\tilde{n}$, the slope of the gross profit function $\pi_i(n)$ is greater than the slope of the price schedule $V(0,n)$. Indeed, by doing so, the firm could increase its profit by $\varepsilon \lim_{n\downarrow\tilde{n}} \partial[\pi_i(n) - V(0,n)]/\partial n > 0$.

Since $\pi_g'(n) > \pi_x'(n) > \pi_a'(n) > 0$, we thus obtain the following result.

Proposition 2. *There exist thresholds $0 \le n_{00} \le n_{01} \le n_{02}$ such that an entrant of type (0,n): (i) exits if $n \in [0,n_{00})$; (ii) is acquired for serving only the domestic market if $n \in (n_{00},n_{01})$; (iii) is acquired for serving the domestic market and serving the foreign market through exports if $n \in (n_{01},n_{02})$; and (iii) is acquired for serving the domestic market and serving the foreign market through greenfield if $n \in (n_{02},\infty)$.*

(The first digit in the subscript of a threshold indicates the value of an entrant's mobile capability.) The stock price of entrant of type $(0,n)$ is then given by

$$V(0,n) = \begin{cases} 0 & \text{if } n \le n_{00}, \\ S[n - n_{00}] & \text{if } n \in [n_{00}, n_{01}], \\ S[n_{01} - n_{00}] + (1+\delta T)S[n - n_{01}] & \text{if } n \in [n_{01}, n_{02}], \\ S[n_{01} - n_{00}] + (1+\delta T)S[n_{02} - n_{01}] + (1+\delta)S[n - n_{02}] & \text{if } n \ge n_{02}. \end{cases} \tag{14}$$

Henceforth, we will assume that parameters are such that $0 < n_{00} < n_{01} < n_{02}$. (It can easily be verified that such parameters exist.)

Consider now an entrant of type $(1,n)$. This entrant's stock price is given by

$$V(1,n) = \max\{V(1,0), Sn + Sn_{00}, (1+\delta T)Sn, (1+\delta)Sn - F_c\}. \tag{15}$$

The first term is the value of the firm conditional on leaving unused the non-mobile capability with which it is endowed. The remaining terms all involve the entrant using its initial non-mobile capability for serving the home market but they differ in how the foreign market is served. The second term is the profit arising from acquiring a foreign entrant of type $(0,n')$ with $n' \in \Delta_a$ to serve the foreign market. From our analysis above, the acquirer must be indifferent between acquiring any foreign target of type $(0,n')$ with $n' \in \Delta_a$, and so it might as well acquire a foreign target of type $(0,n_{00})$ at the stock price $V(0,n_{00}) = 0$. The third term is the profit from serving the foreign market through exports. The last term is the profit from serving the foreign market through greenfield FDI, which requires incurring the fixed coordination cost F_c.

In Eq. (15), we have ordered these terms according to the magnitude of their partial derivatives:

$$0=\frac{\partial V(1,0)}{\partial n}<\frac{\partial}{\partial n}(Sn+Sn_{00})<\frac{\partial}{\partial n}((1+\delta T)Sn)<\frac{\partial}{\partial n}((1+\delta)Sn-F_c).$$

We therefore obtain the following result.

Proposition 3. *There exist thresholds* $0 \leq n_{10} \leq n_{11} \leq n_{12}$ *such that an entrant of type (1,n): (i) leaves its initial non-mobile capability unused (and acquires at least one other entrant) if* $n \in (0, n_{10})$*; (ii) uses its initial non-mobile capability to serve its home market, and acquires a foreign entrant to serve the foreign market if* $n \in (n_{10}, n_{11})$*; (iii) uses its initial non-mobile capability to serve its home market and to serve the foreign market through exports if* $n \in (n_{11}, n_{12})$*; (iv) uses its initial non-mobile capability to serve its home market and to serve the foreign market through greenfield if* $n \in (n_{12}, \infty)$*.*

Henceforth, we will assume that parameters are such that $0<n_{10}<n_{11}<n_{12}$. (It can easily be verified that such parameters exist.) It follows immediately from Eq. (15) that the thresholds are given by:

$$n_{10}=\frac{V(1,0)-Sn_{00}}{S}, \tag{16}$$

$$n_{11}=\frac{n_{00}}{\delta T}, \tag{17}$$

$$n_{12}=\frac{F_c}{(1-T)\delta S}. \tag{18}$$

So far, we have considered the two pools of entrants (those that are endowed with a viable mobile capability and those that are not) separately. The following lemma establishes a relationship between the different sets of thresholds.

Lemma 1. *The two sets of thresholds,* $\{n_{00}, n_{01}, n_{02}\}$ *and* $\{n_{10}, n_{11}, n_{12}\}$ *are related as follows: (i)* $n_{00} \leq n_{01}$*; (ii)* $n_{01} \geq n_{11}$*; and (iii)* $n_{02} = n_{12}$*.*

Proof. See Appendix. □

From Proposition 3, an entrant of type $(1,n)$ with $n \in [0,n_{10}]$ acquires at least one other entrant. By our convention, it will acquire an entrant in the home market. But it may also acquire a foreign target. Let $\lambda \in (0, 1]$ be the fraction of these entrants that acquire only one target (namely one of type $n'>n_{01}$). The remaining fraction $1-\lambda \in (0, 1]$ of these entrants acquire a target of type $n' \in (n_{00}, n_{01})$ in each country. Note that λ is an endogenous variable.

There are two merger-market clearing conditions. First, consider the merger-market clearing condition for the targets of type $(0,n)$ with $n'>n_{01}$:

$$(1-v)E[1-G(n_{01})]=\lambda vEG(n_{10}). \tag{19}$$

On the l.h.s. is the mass of such targets in any one country, while on the r.h.s. is the mass of acquirers of such targets, all of which are domestic firms. Second, consider the merger market clearing condition for the targets of type $(0,n)$ with $n \in (n_{00}, n_{01})$:

$$(1-v)E[G(n_{01})-G(n_{00})] = 2(1-\lambda)vEG(n_{10}) + vE[G(n_{11})-G(n_{10})]. \quad (20)$$

On the l.h.s. is the mass of such targets in any one country, while on the r.h.s. is the mass of acquirers of such targets. The first term on the r.h.s. are those entrants of type $(0, n)$ with $n \in [0, n_{10})$ that acquire one target in each country; hence, half of these acquirers are foreign entrants. The second term on the r.h.s. are entrants of type $(1,n)$ with $n \in (n_{10}, n_{11})$ that use their non-mobile capability to serve their home market and take over a foreign entrant to serve the foreign market; hence, all of these acquirers are foreign entrants. The following proposition summarizes the international organization of production in industry N.

Proposition 4. *If $v<1/2$, then $\lambda<1$, and $n_{00}=n_{10}$, $n_{01}=n_{11}$, and $n_{02}=n_{12}$. If $v>1/2$, then $\lambda=1$, and $n_{00}<n_{10}$, $n_{01}>n_{11}$, and $n_{02}=n_{12}$.*

Proof. See Appendix. □

Figs. 2 and 3 illustrate the international organization of production for the two cases, $v<1/2$ and $v>1/2$, respectively. We begin our discussion with the case $v<1/2$, *i.e.*, the probability that an entrant draws a viable mobile capability is less than fifty percent. Consider an entrant of type $(1,n)$. If $n \in [0, n_{10})$, the entrant will not use the non-mobile capability with which it is endowed but rather acquire a domestic target of type $(0,n)$ with $n>n_{00}$ to serve the home market. Should the entrant acquire a domestic target of type $(0,n')$ with $n' \in (n_{00}, n_{01})$, which occurs with probability $1-\lambda$, then the entrant will also acquire a foreign target of type $(0,n'')$ with $n'' \in (n_{00}, n_{01})$ to serve the foreign market. Should the entrant acquire a domestic target of type $(0,n')$ with $n' \in (n_{01}, n_{02})$

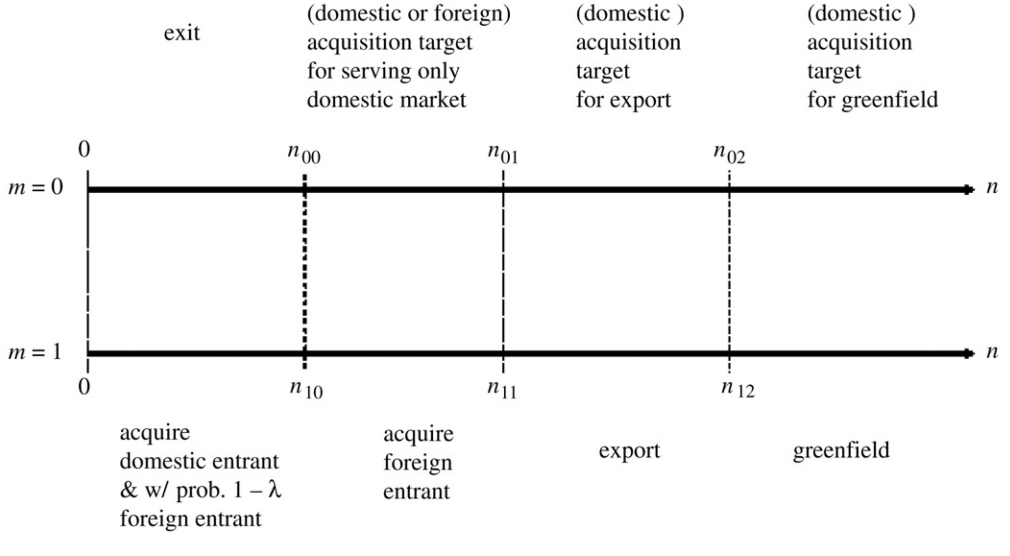

Fig. 2. The international organization of production in industry N when $v<1/2$.

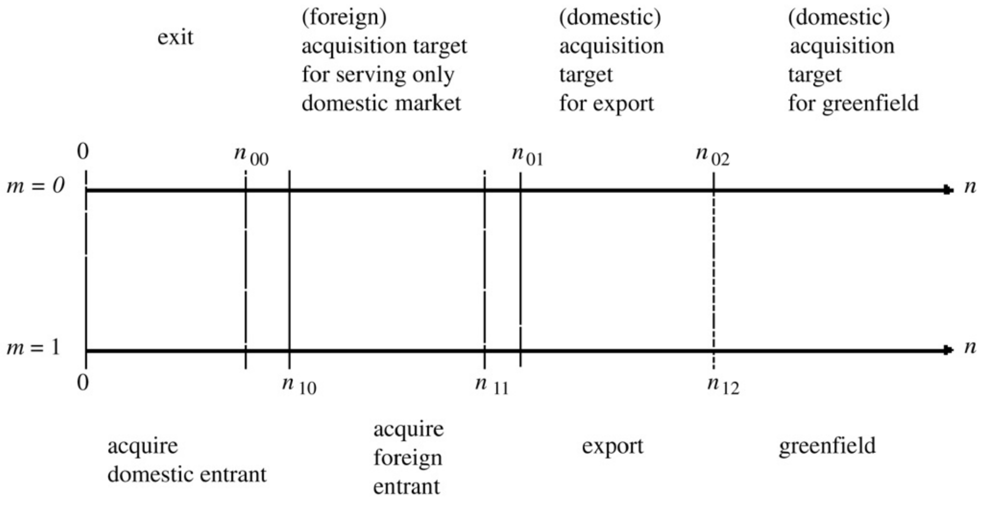

Fig. 3. The international organization of production in industry N when $v>1/2$.

or with $n'\in(n_{02},\infty)$ then the merged firm will subsequently serve the foreign market through exports or greenfield, respectively. If the entrant's non-mobile capability satisfies $n>n_{01}$, the entrant will use its initial non-mobile capability to serve its home market. If $n\in(n_{11},n_{12})$, the entrant will serve the foreign market through exports, while if $n\in(n_{12},\infty)$, it will serve the foreign market through greenfield. We now turn to the case $v>1/2$. In this case, entrants with viable mobile capabilities are relatively abundant, and so (in contrast to the case $v<1/2$), all mergers involve only two entrants. In particular, any entrant of type $(1,n)$ with $n<n_{10}$ will acquire only a domestic target, and so the target must be of type $(0,n')$ with $n'\geq n_{01}$.

Each entrant can be viewed as a "bundle" of a mobile and a non-mobile capability. While the merger market allows firms to combine their capabilities, it does not allow separate trade of mobile and non-mobile capabilities. Therefore, the way in which a non-mobile capability is ultimately used by a firm depends in general not only on how valuable this non-mobile capability is but also on whether or not it was originally bundled with a viable mobile capability. For instance, if $n\in(n_{00},n_{01})$, a non-mobile capability will ultimately be used to serve only the home market, provided this n was originally bundled with a non-viable mobile capability. But when $v>1/2$, the same n may be used differently if it were originally bundled with a viable mobile capability: if $n\in(n_{10},n_{11})\subset(n_{00},n_{01})$, it would be used to serve only the home market, but if $n\in(n_{00},n_{10})$, it would remain idle, and if $n\in(n_{11},n_{01})$, it would be used for exports. Perhaps surprisingly, when acquisition targets are sufficiently abundant, $v>1/2$, the equilibrium outcome is as if mobile and non-mobile capabilities could be unbundled.[9]

3.3. Discussion

Our model provides a rich set of empirical predictions on the relationship between firm efficiency and firm size on the one hand and the mode in which a firm served the foreign

[9] Indeed, in our earlier working paper, Nocke and Yeaple (2004a,b), we assume that mobile and non-mobile capabilities can be unbundled, and the resulting equilibrium outcome is the same as in the present model when $v>1/2$.

market on the other. Given that firms change identities through mergers and acquisitions, it is convenient to analyze this relationship from an ex-post perspective (*i.e.*, after stage 4). We associate the "nationality" of a firm with the country of origin of its (best) mobile capability. In our model, it is natural to measure the domestic efficiency of a firm of type (m,n^1,n^2) from country k by mn^k since domestic gross profits and domestic sales are both proportional to mn^k.

In both industries M and N, those firms that served the foreign market through greenfield FDI (*i.e.*, those firms that produced locally in the foreign market but without using a non-mobile capability specific to that country) were more efficient than those firms that engaged in exporting. Where the predictions for the two industries differ is in the efficiencies of those firms that engaged in cross-border mergers and acquisitions (*i.e.*, of those firms that produced locally in the foreign market using a non-mobile capability specific to that country) relative to those that engaged in exporting or greenfield FDI. Firms that engaged in cross-border M&A are the most efficient in industry M but the least efficient in industry N.

This difference between the two industries is the result of a "superstar" phenomenon (Rosen, 1981): the market allocates the best heterogeneous capabilities to serve the largest market. To see this, note that the existence of trade frictions in our model — transport costs and imperfect mobility of marketing — reduces the "effective" size of markets. Consider first industry M, where the mobile capability m is heterogeneous. The existence of trade frictions implies that mobile capabilities used for cross-border mergers serve an effectively larger market than those used for either exports or greenfield FDI. Since the best mobile capabilities are the "superstars" in this industry, they are assigned to cross-border mergers in the competitive equilibrium. By contrast, in industry N, where it is the non-mobile capability n that is heterogeneous, non-mobile capabilities used for cross-border mergers serve an effectively smaller market (one country rather than two) than those used for either exports or greenfield FDI. Since the best non-mobile capabilities are the "superstars" in this industry, cross-border mergers are assigned the worst active non-mobile capabilities in the competitive equilibrium.

By focussing on two polar cases, industries M and N, we have thus identified an important determinant of the international organization of production: *the source of firm heterogeneity.*[10]

4. Comparative statics

In this section, we analyze the effects of changes in (i) transport costs (or tariffs) and (ii) the degree of mobility of "marketing expertise" n on the international organization of production. We show that the source of firm heterogeneity has wide-ranging implications for the effects of these changes on the efficiency of the least efficient active firm. In the interest of brevity, we assume that $v<1/2$ in industry N so that $n_{00}=n_{10}=n_0$, $n_{01}=n_{11}=n_1$, and $n_{02}=n_{12}=n_2$.[11]

[10] If we were to assume two-sided heterogeneity in both the mobile and non-mobile capabilities, a complex interaction between countervailing effects would arise. From our discussion of the superstar phenomenon, cross-border mergers would involve the best mobile capabilities and the worst non-mobile capabilities. However, complementarities between mobile and non-mobile capabilities (as assumed in our model) would imply positive assortative matching, *i.e.*, the best non-mobile capabilities would be employed with the best mobile capabilities. General analytical results for the case of two-sided heterogeneity are therefore unavailable.

[11] The qualitative results are the same in the case $v\geq 1/2$. The proofs for this case can be obtained from the authors upon request.

We first consider the effects of a change in transport costs (or tariffs) on the international organization of production.

Proposition 5. *Consider a decrease in transport costs, i.e., an increase in T.*

(a) *Then, in industry M,*

$$dS<0, dm_0<0, dm_1>0, dm_2>0.$$

(b) *Then, in industry N,*

$$dS<0, dn_0>0, dn_1<0, dn_2>0.$$

Proof. See Appendix. □

In both industries, the primary effect of a decrease in transport costs, *i.e.*, an increase in T, is to change the fraction of firms engaging in foreign direct investment. As T increases, the fraction of entrants engaging in either cross-border M&A or greenfield FDI decreases. However, as long as δ is sufficiently small, cross-border mergers occur even in the limit as $T\rightarrow 1$, while greenfield FDI disappears in the limit. This is a possible explanation as to why most FDI between the US and Europe, where trade barriers are small, is in the form of cross-border M&A rather than greenfield FDI. In contrast, a much larger fraction of FDI between the North and the South, where trade barriers are large, is in the form of greenfield FDI.

We now seek to analyze the effects of a change in δ, the degree of mobility of capability n.

Proposition 6. *Consider an increase in δ, the degree of mobility of capability n.*

(a) *Then, in industry M,*

$$dS<0, dm_0<0, dm_1<0, dm_2>0.$$

(b) *Then, in industry N,*

$$dS<0, dn_0>0, dn_1<0, dn_2<0.$$

Proof. See Appendix. □

In both industries, the primary effect of an increase in the mobility of the less mobile capability n is to change the composition of foreign direct investment. As the mobility of n increases, the ratio between firms engaging in cross-border M&A and those engaging in greenfield FDI decreases. In the limit as $\delta\rightarrow 1$, cross-border mergers disappear, while in the limit as $\delta\rightarrow 0$, greenfield FDI disappears. Hence, for cross-border M&A to occur, there must be some firm capabilities that are imperfectly mobile internationally.

4.1. General discussion of industry effects

The effects of the changes in δ and T on the distribution of firm efficiencies are very different across the two industries. In industry M, an increase in either δ or T reduces the efficiency (m_0) of the marginal active firm, while in industry N, the effect on n_0 is the opposite. The reason for this dichotomy is that the composition of international commerce is very different in the two industries. In industry M, the marginal active firm is an exporter, while in industry N, it is a firm engaging in cross-border M&A. Since an increase in δ or T makes exporting relatively more attractive and cross-border mergers relative less attractive, m_0 has to fall in industry M, while n_0 rises in industry N. These results have important implications for the growing empirical literature on the effects of trade policies on aggregate productivity. Crucially, our theory shows that the empirical relationship between trade costs and aggregate industry efficiency cannot be predicted without prior knowledge of the source of firm heterogeneity in that industry.

5. Discussion

In this section, we discuss some empirical implications of our model and relate them to the existing empirical literature on mode choice and firm heterogeneity.

As discussed earlier in the paper, technological know-how is likely to be mobile across countries and thus corresponds to capability m in our model while marketing expertise is likely to travel less well across countries and thus corresponds to capability n in our model. It is plausible that in R&D-intensive industries the main source of firm heterogeneity is in firms' technological know-how while in advertising-intensive industries the main source of firm heterogeneity is in firms' marketing expertise. That is, R&D-intensive industries are more like industry M while advertising-intensive industries are more like industry N. Our model predicts that the relationship between firm efficiency and mode of foreign market access (export, greenfield, cross-border M&A) differs across industries, and in particular that this relationship depends on R&D and advertising intensity.

A growing empirical literature tests the prediction of HMY that a firm's propensity to engage in FDI is strictly increasing in its productivity. Partly because of data constraints, partly because HMY do not consider cross-border M&A, most of this empirical literature does not distinguish between greenfield FDI and cross-border M&A but rather compares the efficiency of firms engaging in exports to the efficiency of firms engaging in FDI (of either kind). What does our model predict if one pools greenfield FDI and cross-border M&A? In industry M, firms engaging in FDI of either kind are systematically more efficient than firms engaging in exporting. In industry N, this relationship is less clear: firms engaging in greenfield FDI are more efficient but firms engaging in cross-border M&A are less efficient than exporters. However, if δ is sufficiently small, then most FDI in industry N is in the form of cross-border M&A, and so the average efficiency of firms that engage in FDI is lower than that of firms that do not.

Some of the existing empirical work has shown that firms that engage in FDI are more productive than those that do not (Girma and Gorg, 2003; Arnold and Hussinger, 2005), while other studies (Head and Ries, 2003) find less robust support for this prediction. These studies have not, however, addressed the potential for cross-industry variation in the relationship between firm productivity and mode choice. Recent work by Yeaple (2005) tests key predictions of HMY using both cross-country and cross-industry variation in the investment patterns of U.S. firms. He shows that in the aggregate the predictions of HMY are consistent with the data but in certain non-durable goods industries the structure of FDI is precisely the opposite of that predicted by HMY. These are advertising-intensive industries where arguably there is little scope for heterogeneity in production technology but widespread heterogeneity in marketing and distribution (Horst, 1974) — *i.e.*, industries akin to industry N in our model.[12]

[12] Yeaple's data do not allow him to distinguish between greenfield FDI and cross-border M&A. Therefore, he does not provide a direct test of the prediction that, in advertising-intensive industries, firms engaging in cross-border M&A are less efficient than exporters.

We now turn to another set of empirical implications of our model. In both industries M and N, performance-improving domestic and foreign acquisitions always occur to exploit complementarities between capabilities. The two industries differ in the predicted relative post-acquisition performance of establishments acquired by domestic firms and establishments acquired by foreign firms. In industries in which the source of firm heterogeneity is due to internationally mobile factors (industry M) foreign acquisitions should lead to a more substantial improvement in the post-acquisition establishment performance than domestic acquisitions. (In industry M, there is no systematic difference between domestic acquisition targets and foreign acquisition targets but the acquirers of the former are on average less efficient than those of the latter. Consequently, the stage-4 performance of firms that engaged in cross-border M&A is better than that of firms that engaged in domestic M&A.) In industries in which the source of firm heterogeneity is not internationally mobile (industry N), the opposite result obtains: foreign acquisitions should lead to a less dramatic improvement in post acquisition performance than domestic acquisitions. (In industry N, all of the acquisition targets are non-viable as they lack a viable mobile capability but their post-acquisition performance stems from their non-mobile capability, and domestic targets are endowed with a better non-mobile capability than foreign targets.)

These implications suggest the following two-step empirical strategy. First, given an establishment-level panel dataset, one can estimate by industry the difference in the post-acquisition performance of those establishments that were acquired by foreign firms and those that were acquired by domestic firms. Second, these estimates can then be regressed on key industry characteristics that are likely to give rise to firm heterogeneity such as an industry's R&D intensity and advertising intensity. Our model predicts that there should be systematic differences in this performance differential across industries. Datasets with the requisite information do exist.[13]

A comparative statics result of our model common to both industries is that as δ becomes large, cross-border M&A disappears while as δ becomes small, greenfield FDI disappears. In our model, δ is negatively related to the size of "border effects" as measured by the ratio of domestic sales to foreign sales of an exporter, holding fixed transport costs and tariffs.[14] Our model thus predicts a positive relationship between the size of "border effects" and the share of cross-border M&A in total FDI.

6. Conclusion

In this paper, we have developed a general equilibrium model in which firms can choose between three different modes of foreign market access: exporting, greenfield FDI, and cross-border mergers and acquisitions. Our framework is based on three key ideas. First, there is heterogeneity in firms' capabilities. Second, these capabilities differ in their degree of international mobility. Third, firms can participate in a merger market so as to exploit complementarities in their capabilities. We have applied this framework to address two sets of questions: (1) what are the characteristics of firms that choose the different modes of foreign

[13] For instance, Arnold and Sarzynska-Javorcik (2005) compare the post-acquisition performance of domestic and foreign acquisitions on local establishments using a comprehensive establishment-level dataset for Indonesia. They find that on average foreign acquisitions are associated with a greater improvement in performance than domestic acquisitions, but they do not disaggregate by industry. Girma and Gorg (2003) use UK establishment-level data to compare the performance of foreign acquisitions versus firms that were not acquired. They show that the relative performance does in fact vary across industries, but do not explicitly compare domestic versus foreign acquisitions and their cross industry variation is limited to only two industries. This cross-industry heterogeneity does suggest, however, that industry characteristics are likely to matter.

[14] There is a large empirical literature in international trade on border effects (*e.g.*, McCallum, 1995).

market access, and (2) what are the effects of country and industry characteristics on this international organization of production?

A main result of our analysis is that the source of firm heterogeneity is a critical industry characteristic for the international organization of production. Depending on whether firms differ in their mobile or non-mobile capabilities, cross-border M&A involves either the most or the least efficient active firms. The source of firm heterogeneity also plays an important role for the effects of country and industry characteristics on the distribution of firm efficiencies. Our analysis has also highlighted the importance of the merger market clearing condition for the predictions of our model. Since the changes in country and industry characteristics directly impact upon entrants' participation decisions on the merger market, the effect of these characteristics on aggregate industry efficiency is mediated by the merger market.

In this paper, we have assumed that countries are of the same size. In a previous version of the paper, Nocke and Yeaple (2004b), we investigated the effects of asymmetric changes in country size on the international organization of production. There, we showed that country size "matters" and that its effect crucially depends on the source of firm heterogeneity. In this paper, we have also assumed that, in each industry, there is only one source of firm heterogeneity: either in mobile or in non-mobile capabilities. In Nocke and Yeaple (2004a), we allow for general two-sided heterogeneity but, for reasons of tractability, abstract from trade costs.

Our theory may fruitfully be used as a framework to inform government policies toward international commerce. Because cross-border M&A involves the acquisition of a local firm by a foreign multinational enterprise, cross-border M&A brings "less" to the host country's economy than greenfield FDI. Moreover, as our analysis has shown, firms with different capabilities choose different modes of foreign market access. Hence, the optimal government policy toward foreign direct investment should be tailored to the particular type of FDI: greenfield *vs.* cross-border M&A. A rigorous analysis of the policy implications of our theory, however, raises a number of modeling issues (government objectives, set of policy instruments) that we plan to address in a separate paper.

Appendix A

A.1. Free entry condition in industry M

Applying the distributional assumptions, the free entry condition, Eq. (8), becomes

$$\mu \int_0^\infty V(m,1)dH(m) + (1-\mu)\int_0^\infty V(m,0)dH(m) - F_e = 0.$$

Using

$$V(m,0) = \max\{0, V(m,1) - V(0,1)\}$$

and

$$V(m,1) = V(0,1) \text{ for } m \le m_0,$$

the free entry condition becomes

$$\int_{m_0}^\infty V(m,1)dH(m) + [\mu H(m_0) - (1-\mu)(1-H(m_0))]V(0,1) - F_e = 0.$$

Expanding this expression using Eq. (9), and simplifying using the merger market clearing condition (13), we obtain

$$S\left\{\int_{m_0}^{\infty} mdH(m) + T\delta\int_{m_0}^{m_1} mdH(m) + \delta\int_{m_1}^{m_2} mdH(m) + \int_{m_2}^{\infty} mdH(m)\right\} \\ -F_c[H(m_2)-H(m_1)]-F_e = 0. \tag{21}$$

A.2. Free entry condition in industry N

Applying the distributional assumptions, the free entry condition, Eq. (8), becomes

$$v\int_0^{\infty} V(1,n)dG(n) + (1-v)\int_0^{\infty} V(0,n)dG(n)-F_e = 0.$$

All entrants of type $(1,n)$, $n\le n_{10}$, do not use their non-mobile capability and so have value $V(1,0)$. All entrants of type $(0,n)$, $n\le n_{00}$, exit, and so have value $V(0,\mathrm{n})=0$. The free entry condition can thus be rewritten as

$$vG(n_{10})V(1,0) + v\int_{n_{10}}^{\infty} V(1,n)dG(n) + (1-v)\int_{n_{00}}^{\infty} V(0,n)dG(n)-F_e = 0.$$

Substituting out $V(0,n)$ using Eq. (14) and substituting out $V(1,n)$ using Eq. (15), the free entry condition becomes

$$\begin{aligned} &vG(n_{10})V(1,0) \\ &\quad + v\left\{\int_{n_{10}}^{n_{11}} S(n+n_{00})dG(n) + \int_{n_{11}}^{n_2} Sn(1+T\delta)dG(n) + \int_{n_2}^{\infty} [Sn(1+\delta)-F_c]dG(n)\right\} \\ &\quad + (1-v)\left\{S\int_{n_{00}}^{n_{01}} (n-n_{00})dG(n) + S\int_{n_{01}}^{n_2} [(n-n_{00}) + T\delta(n-n_{01})]dG(n)\right. \\ &\quad \left. + S\int_{n_2}^{\infty} [(n-n_{00}) + T\delta(n_2-n_{01}) + \delta(n-n_2)]dG(n)\right\}-F_e = 0, \end{aligned} \tag{22}$$

where $n_2=n_{02}=n_{12}$.

For the case considered in the comparative statics ($v<1/2$), the free entry condition can be simplified considerably. By Proposition 4, we have $n_{01}=n_{11}\equiv n_1$ and $n_{00}=n_{10}\equiv n_0$, so that the threshold conditions become

$$n_0 = T\delta n_1,$$

$$2Sn_0 = V(1,0),$$

and $S\delta(1-T)n_2 = F_c.$

Hence, the free entry condition (22) can be rewritten as

$$S\left\{\int_{n_0}^{\infty} ndG(n) + T\delta\int_{n_1}^{n_2} ndG(n) + \delta\int_{n_2}^{\infty} ndG(n)\right\}$$
$$-[1-G(n_2)]F_c - F_e - Sn_0\{2(1-v)-G(n_0)-G(n_1)\} = 0,$$

and the merger market clearing conditions (19) and (20) become

$$(1-v)[1-G(n_1)] = \lambda vG(n_0)$$

and

$$(1-2v)[G(n_1)-G(n_0)] = 2(1-\lambda)vG(n_0).$$

Multiplying the first condition by two and adding it to the second condition yields

$$2(1-v)-G(n_1)-G(n_0) = 0. \tag{23}$$

Applying this merger market clearing condition, the free entry condition for the case $v<1/2$ simplifies to

$$S\left\{\int_{n_0}^{\infty} ndG(n) + T\delta\int_{n_1}^{n_2} ndG(n) + \delta\int_{n_2}^{\infty} ndG(n)\right\} - F_c[1-G(n_2)] - F_e = 0. \tag{24}$$

Proof of Lemma 1. Consider an entrant of type $(0,n)$ with $n\in(n_{01}, n_{02})$. Such an entrant will be acquired to serve the home market, and the foreign market through exports. But as we have just shown, the only acquirers are the entrants of type $(1,n)$ with $n\in(0, n_{10})$. The stock price of these acquirers is therefore

$$V(1,0) = (1+\delta T)Sn' - V(0,n'), n'\in\Delta_x,$$

which can be re-written as

$$V(1,0) = \delta TSn_{01} + Sn_{00}. \tag{25}$$

We also have

$$V(1,0) = Sn_{10} + Sn_{00}$$

$$= Sn_{10} + \delta TSn_{11}, \tag{26}$$

where the first equality follows from Eq. (16) and the second equality from Eq. (17). Using Eqs. (25) and (26), we obtain

$$S(n_{10}-n_{00}) = \delta TS(n_{01}-n_{11}). \tag{27}$$

We now claim that $n_{10}\geq n_{00}$, and so, from the above equation, $n_{01}\geq n_{11}$. To see this, suppose otherwise that $n_{10}<n_{00}$. Since $V(1,n)$ is strictly increasing in n for $n\geq n_{10}$, it then follows that $V(1,n_{10})<V(1,n_{00})$. But an entrant of type $(1,n_{10})$ could acquire another entrant of type $(0,n_{00})$ at the stock market price $V(0,n_{00})=0$ and increase its profit to $V(1,n_{00})$: a contradiction.

Consider now an entrant of type (0,n) with $n > n_{02}$. Such an entrant will be acquired to serve the home market, and to serve the foreign market through greenfield FDI. But the only acquirers are the entrants of type (1,n) with $n \in (0, n_{10})$. The value of these acquirers is therefore

$$V(1,0) = (1+\delta)Sn' - V(0,n'), n' \in \Delta_g,$$

which can be re-written as

$$V(1,0) = Sn_{00} + \delta S[(1-T)n_{02} + Tn_{01}] - F_c.$$

Comparing this expression with Eq. (25), we obtain

$$n_{02} = \frac{F_c}{(1-T)\delta S}.$$

From (18), it follows that $n_{02} = n_{12}$. □

Proof of Proposition 4.

Step 1 We claim that if $\lambda < 1$, then $n_{00} = n_{10}$ and $n_{01} = n_{11}$. From Lemma 1, $n_{00} \leq n_{10}$ and $n_{01} \geq n_{11}$. We now show that $n_{00} = n_{10}$ and $n_{01} = n_{11}$ if $\lambda < 1$. To see this, note that if $\lambda < 1$, then an entrant of type (1,n) with $n < n_{10}$ has to be indifferent between acquiring a domestic target of type (0,n') with $n' > n_{01}$ – resulting in a profit of $S(n_{00} + T\delta n_{01})$ – and acquiring two targets (one in each country) of type (0,n') with $n' \in (n_{00}, n_{01})$ — resulting in a profit of $2Sn_{00}$. Hence,

$$2Sn_{00} = S(n_{00} + T\delta n_{01}),$$

and so,

$$n_{01} = \frac{n_{00}}{\delta T} = n_{11},$$

where the second equality follows from Eq. (17). Eq. (27) then implies $n_{00} = n_{10}$.

Step 2 Consider the case $v < 1/2$. From Lemma 1, $n_{00} \leq n_{10}$ and $n_{01} \geq n_{11}$ which implies that $G(n_{11}) - G(n_{10}) \leq G(n_{01}) - G(n_{00})$. Suppose that, contrary to the claim of the proposition, $\lambda = 1$. But then the l.h.s. of Eq. (20) is larger than the r.h.s.; a contradiction. Hence, $\lambda < 1$. From step 1, it follows that $n_{00} = n_{10}$ and $n_{01} = n_{11}$.

Step 3 Consider now the case $v > 1/2$. Suppose that, contrary to the claim of the proposition, $\lambda < 1$. From step 1, it follows that $n_{00} = n_{10}$ and $n_{01} = n_{11}$. The stock market clearing condition (20) can then be rewritten as

$$(1-2v)E[G(n_{01}) - G(n_{00})] = 2(1-\lambda)vEG(n_{10}).$$

Since $v \geq 1/2$, the l.h.s. is nonpositive, while the r.h.s. is strictly positive as $\lambda < 1$; a contradiction. Hence, $\lambda = 1$, and so from the merger-market clearing condition (20),

$$G(n_{01}) - G(n_{00}) > G(n_{11}) - G(n_{10}). \tag{28}$$

Note also that Eqs. (16) and (25) imply that

$$n_{10} = \delta T n_{01}. \tag{29}$$

We now show that $n_{00}<n_{10}$ and $n_{01}>n_{11}$. We proceed in two steps. First, suppose otherwise that $n_{00}=n_{10}$. Then, from Eq. (29), $n_{00}=\delta T n_{01}$, and from Eq. (17), $n_{00}=\delta T n_{11}$. Hence, $n_{01}=n_{11}$. But this contradicts Eq. (28). From Lemma 1, $n_{00}\leq n_{01}$, and so it follows that $n_{00}<n_{00}$. Second, suppose otherwise that $n_{01}=n_{11}$. Then, from Eq. (29), $n_{10}=\delta T n_{11}$, and from Eq. (17), $n_{00}=\delta T n_{11}$. Hence, $n_{10}=n_{00}$. But this contradicts Eq. (28). From Lemma 1, $n_{01}\geq n_{11}$, and so it follows that $n_{01}>n_{11}$. □

Proof of Proposition 5.

Case (a) Industry M. We begin by totally differentiating the free entry condition (21) to obtain

$$dS\left\{\int_{m_0}^{\infty} mdH(m) + T\delta\int_{m_0}^{m_1} mdH(m) + \delta\int_{m_1}^{m_2} mdH(m) + \int_{m_2}^{\infty} mdH(m)\right\}$$
$$-S(1+T\delta)m_0 h(m_0) - [s\delta(1-T)m_1 + F_c]h(m_1)dm_1$$
$$-[S(1-\delta)m_2 - F_c]h(m_2)dm_2 + \left\{\delta\int_{m_0}^{m_1} mdH(m)\right\}dT = 0.$$

Using the threshold conditions (10)–(12), this equation can be rewritten as

$$dS\left\{\int_{m_0}^{\infty} mdH(m) + T\delta\int_{m_0}^{m_1} mdH(m) + \delta\int_{m_1}^{m_2} mdH(m) + \int_{m_2}^{\infty} mdH(m)\right\}$$
$$-V(0,1)[h(m_0)dm_0 - h(m_2)dm_2] + \left\{\delta\int_{m_0}^{m_1} mdH(m)\right\}dT = 0.$$

Totally differentiating the merger market clearing condition (13) yields

$$h(m_0)dm_0 - h(m_2)dm_2 = 0 \tag{30}$$

and

$$\frac{dS}{S} = -\frac{T\delta\int_{m_0}^{m_1} mdH(m)}{\int_{m_0}^{\infty} mdH(m) + T\delta\int_{m_0}^{m_1} mdH(m) + \delta\int_{m_1}^{m_2} mdH(m) + \int_{m_2}^{\infty} mdH(m)}\frac{dT}{T}. \tag{31}$$

Hence, $dSdT<0$. Next, totally differentiate the threshold condition (11) to obtain

$$\frac{dm_1}{m_1} = \frac{dT}{1-T} - \frac{dS}{S}.$$

Since $dSdT<0$, it follows that $dm_1dT>0$.
Combining the remaining threshold equations, Eqs. (10) and (12), yields

$$(1-\delta)m_2 = (1+T\delta)m_0 - \frac{F_c}{S}.$$

Totally differentiating this expression yields

$$(1-\delta)dm_2 = (1+T\delta)dm_0 + \delta m_0 dT - \frac{F_c}{S}\frac{dS}{S} = 0. \tag{32}$$

Substituting for m_0 using Eqs. (30) and (32), we obtain

$$dm_2\left[1-\delta + (1+T\delta)\frac{h(m_0)}{h(m_2)}\right] = \delta m_0 dT - \frac{F_c}{S}\frac{dS}{S}.$$

Since $dSdT<0$, it follows immediately that $dm_2dT>0$ and $dm_0dT<0$.

Case (b) Industry N (when $v<1/2$). Totally differentiating the free entry condition (24), we find

$$\begin{aligned}&\frac{dS}{S}\{F_c[1-G(n_2)]+F_e\}-Sn_0g(n_0)dn_0\\&+ST\delta n_2g(n_2)dn_2-ST\delta n_1g(n_1)dn_1-S\delta n_2g(n_2)dn_2+F_cg(n_2)dn_2\\&+S\delta\left\{\int_{n_1}^{n_2}ndG(n)\right\}dT\\&=0.\end{aligned}$$

Using the threshold condition (18), this expression simplifies to

$$\begin{aligned}&\frac{dS}{S}\{F_c[1-G(n_2)]+F_e\}-Sn_0g(n_0)dn_0-ST\delta n_1g(n_1)dn_1-S\delta\left\{\int_{n_1}^{n_2}ndG(n)\right\}dT\\&=0.\end{aligned}$$

Totally differentiating the merger market clearing condition (23), we obtain

$$g(n_1)dn_1=-g(n_0)dn_0. \tag{33}$$

Combining this expression with the threshold condition (17) and substituting it into to the derivative of the free entry condition yields

$$\frac{1}{S}\frac{dS}{dT}=-\frac{S\delta\int_{n_1}^{n_2}ndG(n)}{F_c[1-G(n_2)]+F_e}.$$

Hence, $dSdT<0$. Finally, totally differentiating (17), we obtain

$$dn_0=\delta Tdn_1+\delta n_1dT.$$

Combining this expression with Eq. (33), establishes $dn_0dT>0$ and $dn_1dT<0$. Finally, totally differentiate Eq. (18) to obtain

$$\frac{1}{S}\frac{dS}{dT}-\frac{n_2}{1-T}+\frac{dn_2}{dT}=0.$$

Since $dSdT<0$, it then follows that $dn_2dT>0$. □

Proof of Proposition 6.

Case (a) Industry M. We begin by totally differentiating the threshold condition for m_1, Eq. (11). This yields

$$\frac{dm_1}{m_1}=-\frac{dS}{S}-\frac{d\delta}{\delta}. \tag{34}$$

Total differentiation of the free entry condition (21) yields

$$\begin{aligned}&dS\left\{\int_{m_0}^{\infty}mdH(m)+T\delta\int_{m_0}^{m_1}mdH(m)+\delta\int_{m_1}^{m_2}mdH(m)+\int_{m_2}^{\infty}mdH(m)\right\}\\&-S(1+T\delta)m_0h(m_0)-[S\delta(1-T)m_1+F_c]h(m_1)dm_1\\&-[S(1-\delta)m_2+F_c]h(m_2)dm_2+\left\{T\int_{m_0}^{m_1}mdH(m)+\int_{m_1}^{m_2}mdH(m)\right\}d\delta=0.\end{aligned}$$

Substituting the threshold conditions (10)–(12), and the total derivative of the merger market clearing condition (30), we obtain

$$\frac{dS}{S}=-\frac{T\delta\int_{m_0}^{m_1} mdH(m)+\delta\int_{m_1}^{m_2} mdH(m)}{\int_{m_0}^{\infty} mdH(m)+T\delta\int_{m_0}^{m_1} mdH(m)+\delta\int_{m_1}^{m_2} mdH(m)+\int_{m_2}^{\infty} mdH(m)}\frac{d\delta}{\delta}. \tag{35}$$

From Eq. (35), we obtain that $dSd\delta<0$. Since the absolute value of the coefficient in front of $d\delta$ is less than one, it then follows from Eq. (34) that $dm_1 d\delta<0$.Combining the remaining threshold equations, (10) and (12), yields

$$(1-\delta)m_2=(1+T\delta)m_0-\frac{F_c}{S}.$$

Totally differentiating this expression yields

$$(1-\delta)dm_2=(1+T\delta)dm_0+(m_2+Tm_0)d\delta-\frac{F_c}{S}\frac{dS}{S}.$$

Using the total derivative of the merger market clearing condition (30) we obtain

$$dm_2\left[1-\delta+(1+T\delta)\frac{h(m_0)}{h(m_2)}\right]=(m_2+Tm_0)d\delta-\frac{F_c}{S}\frac{dS}{S}.$$

Since $dSd\delta<0$, it follows that $dm_2d\delta>0$. From the derivative of the merger market clearing condition, it follows immediately that $dm_2 d\delta<0$.

Case (b) Industry N (when $v<1/2$). Start by totally differentiating Eq. (17). This yields

$$dn_0=Tn_1d\delta+T\delta dn_1.$$

Combining this expression with Eq. (33) yields

$$dn_0\left[1+\frac{g(n_0)}{g(n_1)}T\delta\right]=Tn_1d\delta,$$

which implies $dn_0d\delta>0$. It follows immediately from Eq. (33) that $dn_1d\delta<0$. Totally differentiating Eq. (24), we obtain

$$\begin{aligned}&\frac{dS}{S}\left\{\int_{n_0}^{\infty} ndG(n)+T\delta\int_{n_1}^{n_2} ndG(n)+\delta\int_{n_2}^{\infty} ndG(n)\right\}-Sn_0g(n_0)dn_0\\&+ST\delta n_2g(n_2)dn_2-ST\delta n_1g(n_1)dn_1-S\delta n_2g(n_2)dn_2+F_cg(n_2)dn_2\\&+\left\{T\int_{n_1}^{n_2} ndG(n)+\int_{n_2}^{\infty} ndG(n)\right\}d\delta\\&=0.\end{aligned}$$

Using the threshold conditions (17), (18), and (33), this expression simplifies to

$$\frac{dS}{S}=-\frac{T\delta\int_{n_1}^{n_2} ndG(n)+\delta\int_{n_2}^{\infty} ndG(n)}{\int_{n_0}^{\infty} ndG(n)+T\delta\int_{n_1}^{n_2} ndG(n)+\delta\int_{n_2}^{\infty} ndG(n)}\frac{d\delta}{\delta}.$$

Hence, $dSd\delta < 0$.

Now totally differentiate Eq. (18) to obtain

$$\frac{dn_2}{n_2} = -\left(\frac{dS}{S} + \frac{d\delta}{\delta}\right).$$

Substituting for dS/S, we have

$$\frac{dn_2}{n_2} = -\frac{\int_{n_0}^{\infty} ndG(n)}{\int_{n_0}^{\infty} ndG(n) + T\delta \int_{n_1}^{n_2} ndG(n) + \delta \int_{n_2}^{\infty} ndG(n)} \frac{d\delta}{\delta}.$$

Hence, $dn_2 d\delta < 0$. □

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