An Assignment Theory of Foreign Direct Investment*

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Abstract

We develop a theory of international trade, where foreign direct investment arises because of factor price differences across countries and because of differences in the distributions of heterogeneous firm-specific assets. Firms conduct foreign direct investment by either engaging in greenfield investment or by acquiring foreign firm-specific assets on the international merger market. We show that most foreign direct investment takes the form of cross-border acquisitions when factor price differences are small, while greenfield investment plays a more important role for foreign direct investment from high-wage into low-wage countries. Moreover, we show that firms engaging in greenfield investment are systematically more efficient than those engaging in cross-border acquisitions. Both predictions are confirmed by our empirical analysis of the investment behavior of U.S. multinationals. Our results show that foreign direct investment flows cannot properly be understood without distinguishing between its two modes, greenfield investment and cross-border acquisitions.

JEL Codes: F12, F23.

Keywords: Foreign Direct Investment, Mergers, Greenfield, Firm Heterogeneity.

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1 Introduction

Multinational enterprises (MNEs) play a dominant role in an increasingly globalized world. In 1999, the domestic operations of the approximately 2,400 U.S. multinational enterprises accounted for approximately 26 percent of U.S. GDP, 63 percent of U.S. exports, 37 percent of U.S. imports, and 68 percent of U.S. R&D expenditures (Mataloni and Yorganson, 2002). That year, nearly half of all U.S. manufacturing workers were employed by U.S. multinationals.

Despite their economic importance, the investment decisions of multinationals are not well understood. In this paper, we reveal striking empirical regularities in the choice of multinationals between building new affiliates abroad (greenfield foreign direct investments) and taking over existing foreign enterprises (cross-border acquisitions). We establish that multinationals engaging in greenfield foreign direct investment are systematically different from those engaging in cross-border acquisitions. Moreover, the choices between these modes of foreign direct investment (FDI) systematically differ with the host country’s level of development. These empirical regularities motivate our theory of foreign direct investment, in which firms differ in their endowments of firm-specific assets, and cross-border acquisitions allow firms to exploit complementarities in these firm-specific assets. By uncovering a new motive for firms to engage in FDI, one which is unique to cross-border acquisitions, our theory provides a novel perspective on both the investment decisions of individual multinationals and aggregate FDI flows across countries.

At the aggregate level, both greenfield FDI and cross-border acquisitions are large in magnitude. However, there is considerable variation in the composition of FDI mode choice across host countries. This is illustrated in figure 1, where we plot the number of cross-border acquisitions as a fraction of U.S. outward FDI by income group of the host country.1 As figure 1 reveals, there is a strong positive relationship between a host country’s level of development and the propensity of U.S. firms to favor cross-border acquisitions over greenfield FDI. A potential concern is that the observed differences across countries are due to cross-country differences in the industrial composition of FDI. Figure 1 shows that the relationship between country income and the share of cross-border acquisitions in total FDI is virtually unchanged if we keep the industrial composition of FDI constant across countries. As our econometric analysis will confirm, in each industry there is a strong positive correlation between country income and the propensity of U.S. multinationals to favor cross-border acquisitions over greenfield FDI.

There is considerable variation in the composition of FDI mode choice not only across countries, but also across individual multinationals. In fact, as we will show using a unique firm-level data set, U.S. multinationals that engage in greenfield FDI are systematically more productive than those multinationals that engage in cross-border acquisitions. This finding may help explain why the governments of many host countries favor greenfield FDI over cross-border acquisitions.

The observed pattern of FDI mode choice across firms and host countries raises important

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1 The figure is based on data compiled by the Bureau Economic Analysis. We describe the data in more detail in section 2. The measure of the composition of mode choice for outward FDI is the fraction of new U.S. manufacturing enterprises abroad that were acquired rather than created through greenfield. The forty-five host countries are assigned to three equally-sized bins, according to their GDP per capita.
issues that must be addressed by any model. (1) In what dimensions do firms differ? (2) Why do firms merge? What is the nature of the difference between cross-border acquisition and greenfield FDI? (3) Why does firms’ mode choice, conditional on engaging in FDI in a given country, differ across host countries? What makes countries different from the view point of multinationals?

In this paper, we develop a theory of foreign direct investment to explain the pattern of FDI mode choice. The key features of our model are as follows. (1) Each firm consists of two sets of complementary assets: assets that are perfectly mobile internationally (e.g., entrepreneurial ability or organizational capital), and assets that are costly to move from one country to another (e.g., capabilities embodied in physical capital). There is heterogeneity across firms in both sets of assets. (2) There exists an international merger market where firm assets are traded. Firms buy and sell assets on this merger market to exploit complementarities. A cross-border acquisition thus involves purchasing foreign assets that the acquirer lacks. In contrast, greenfield FDI involves the costly transfer of assets to the foreign country. (3) The two countries differ in their endowments of assets and factor prices. From the view point of multinationals, countries thus differ in the cost of production and the endogenous prices of firm assets in the merger market.

In our model, foreign direct investment arises for two reasons: cross-country differences in (i) factor prices and in (ii) the shapes of the distributions of firm-specific assets. Factor price differences between countries give rise to both greenfield FDI and cross-border acquisitions. Cross-country differences in the shape of the distributions of firm-specific assets, on the other hand, give rise only to cross-border acquisitions. Greenfield FDI is always one-way: from the high cost to the low cost country. In contrast, cross-border acquisitions occur in both directions: each country serves as both a home and a host country. Hence, our model can generate large two-way FDI flows even in the absence of transportation costs.

A key prediction of our model is that the composition of FDI mode choice varies with
country characteristics. When factor price differences between countries are small, almost all of FDI is in the form of cross-border acquisitions. This may explain why cross-border acquisitions are the dominant mode of FDI between rich and developed countries. This also may explain why a much larger fraction of FDI from rich and developed countries into poor and developing countries is in the form of greenfield FDI.

Turning from the country level to the firm level, our model provides a set of predictions on the relationship between a firm’s efficiency and its FDI mode choice. Consistent with our empirical findings, the model predicts that firms engaging in greenfield FDI are systematically more efficient than firms engaging in cross-border acquisitions or in domestic production. In the high cost country, firms engaging in cross-border acquisitions are, on average, more efficient than firms producing domestically, while the reverse is true for the low country.

While greenfield FDI involves more efficient firms than cross-border acquisitions, both modes of FDI play an important allocative role. Greenfield FDI ensures that the best firm-specific assets are used for production in the low-cost country. Cross-border acquisitions allow those firm-specific assets from one country that are perfectly mobile internationally to be employed with those firm-specific assets from another country that are costly to move. Even in the absence of factor price differences, such efficient reallocation of mobile firm-specific assets occurs as long as there are cross-country differences in the shapes of the distributions of firm-specific assets. In the presence of factor price differences, firm-specific assets are ceteris paribus more productive in the low-cost country than in the high-cost country. Hence, there are efficiency gains from reallocating the mobile firm-specific assets in such a way that the mobile firm-specific assets employed in the low-cost country are, on average, more efficient than those employed in the high-cost country. In our model, both greenfield FDI and cross-border acquisitions allow the selection of the more efficient firms into the more productive location. Hence, any underlying productivity differences between countries will be magnified by the induced reallocation of firm-specific assets.

Related Literature. Our paper is mainly related to two strands in the theoretical trade literature. A feature common to both strands, and shared by our paper, is the assumption that contracting problems prevent arm’s-length relationships.\(^2\)

In our model, FDI arises because of underlying differences across countries, and there is a tendency for each firm to locate production in one country. It is this aspect that our paper shares with the literature on vertical FDI (e.g., Helpman, 1984). Indeed, recent empirical work by Hanson, Mataloni, and Slaughter (2003) documents a tendency for multinationals to concentrate production in low-wage countries. In contrast to our paper, the theoretical literature on vertical FDI does not consider firm heterogeneity, there are no cross-border acquisitions, and hence, at any given stage of production, all FDI is from the country with the comparative disadvantage to the country with the comparative advantage.\(^3\)

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\(^2\)There is, however, an interesting recent (but so far empirically untested) literature that explores the trade-offs between in-house production and outsourcing; see Antras (2003), Antras and Helpman (2004), and Grossman and Helpman (2004).

\(^3\)An exception is the recent paper by Neary (2004) on cross-border acquisitions. In his paper, however, there is no firm heterogeneity, no greenfield FDI, and acquisitions are motivated by market power and are one-way.
We extend the literature on firm heterogeneity and international trade that is concerned with the selection of heterogeneous firms into different modes of serving global markets by introducing an international merger that allows the assortative matching between complementary firm-specific assets from different countries. Within this literature, the two papers that are most closely related to ours are Helpman, Melitz, and Yeaple (2004), and Nocke and Yeaple (2004). However, in Helpman, Melitz, and Yeaple (HMY) there is no motive for firms to engage in cross-border acquisitions, and so greenfield is the only mode of FDI. On the other hand, Nocke and Yeaple (2004) consider cross-border acquisitions but analyze the interaction between trade costs (which are absent in the present model) and the source of firm heterogeneity (mobile versus non-mobile capabilities). The presence of trade costs in Nocke and Yeaple (2004) does not allow the analysis of two-sided heterogeneity, and therefore precludes assortative matching between complementary firm-specific assets, which lies at the heart of the present paper. Another benefit of abstracting from trade costs in the present paper is that it allows us to analyze large country differences.

2 Cross-Border Acquisitions versus Greenfield FDI: The Evidence

In this section, we present a formal econometric analysis of a U.S. multinational’s choice between cross-border acquisition and greenfield FDI when conducting foreign direct investment in a given host country. Our results provide strong evidence that (i) the most productive U.S. firms systematically choose greenfield FDI over cross-border acquisition, and that (ii) U.S. firms are likely to favor cross-border acquisition over greenfield FDI, the richer the host country.

The Econometric Model. We estimate a simple econometric model of a firm’s choice of FDI mode. Conditional on a firm’s decision to enter country \( c \) in industry \( k \), we assume: (i) that each multinational enterprise chooses the mode \( m \in \{ACQ, GF\} \) that yields the highest profits, where \( ACQ \) is cross-border acquisition, and \( GF \) greenfield FDI; and (ii) that the profitability of mode \( m \) for parent firm \( p \) in parent industry \( j \) is given by

\[
\Pi_{mk}(Y_p, Z_c) = \eta_{mj} + \alpha_m Y_p + \gamma_m Z_c + \varepsilon_{kjcp},
\]

where \( Y_p \) is a vector of characteristics for parent firm \( p \), \( Z_c \) a vector of characteristics for country \( c \), and \( \eta_{mj} \) is the inherent “attractiveness” of mode \( m \) for a parent firm in industry \( j \). The unobservable \( \varepsilon_{kjcp} \) is assumed to be Weibull distributed. This formulation of a firm’s choice between cross-border acquisition and greenfield FDI implies a logit model in which the dependent variable is the indicator \( ACQ_{kjcp} \), which takes a value of one when the investment in industry \( k \) and country \( c \) by parent firm \( p \) in parent industry \( j \) takes the form of a cross-border acquisition, and zero otherwise. We normalize the coefficients \( \alpha_{GF} \) and \( \gamma_{GF} \) to zero.

Data. All firm-level data (the dependent variable \( ACQ_{kjcp} \) and parent firm characteristics \( Y_p \)) come from the Bureau of Economic Analysis (BEA). Each year, the BEA conducts a mandatory survey of all U.S. firms with foreign affiliates above a certain size threshold. Firms

\[^4\text{Other papers in the literature on firm heterogeneity include Melitz (2003), Bernard, Eaton, Jensen, and Kortum (2003), and Eaton, Kortum, and Kramarz (2004).}\]
that come to own a new enterprise abroad are required to report (i) whether that enterprise was obtained through cross-border acquisition or greenfield FDI, (ii) in which industry that enterprise produces, and (iii) in which country that enterprise is located. From this database, we collected every recorded investment by those multinationals whose mainline of business is a traded good over the period 1989-1998.

In the construction of our final sample, we classified investments to facilitate interpretation of the results. In particular, we aggregated a firm’s investments over the entire sample period 1989-1998 so that for each firm, a country-industry pair appears at most once. For firms that made more than one investment in a particular country and industry, a country-industry observation for a firm was coded as a cross-border acquisition only if all investments made over the nine-year period in that country-industry cell were cross-border acquisitions, and was coded as a greenfield investment otherwise.5 Formally, $ACQ_{kijcp}$ is equal to one if and only if all investments made in industry $k$ and country $c$ by parent $p$ over the years 1989-1998 involved cross-border acquisitions, and is equal to zero otherwise.

For the purpose of this study, two features of the BEA dataset are particularly notable: (i) each foreign affiliate can be linked to its parent firm, and (ii) a wide range of data are collected for each parent firm. To ensure comparability across firms, each parent firm characteristic is measured for the year 1989 and used to predict a firm’s investment behavior over the subsequent nine-year period.6

The key firm characteristic within the literature on firm heterogeneity and international commerce is the firm’s efficiency (or productivity) relative to its competitors. Given the importance of this firm characteristic in the theoretical literature, we focus most of our attention on measures of a firm’s relative efficiency, treating other firm characteristics as controls. In measuring a firm’s efficiency, we are constrained by the data available from the BEA. Since these data do not include material input costs, we cannot construct measures of total factor productivity. Instead, we consider two proxies that should be highly correlated with total factor productivity. The first of these measures, $USSALES$, is the logarithm of a firm’s sales to customers in the United States. Most models of heterogeneity predict that a firm’s market share is rising in its relative efficiency so that differences in sales across firms in the United States market should reflect efficiency differences across firms. The second measure, $LABORPROD$, is the logarithm of the ratio of total firm sales to number of employees. Since variation in labor productivity could be due to variation in capital intensity or a firm’s scale of operations rather than efficiency, we sometimes include two controls, $CAPLAB$ and $EMP$, which are the logarithm of the ratio of a firm’s net book value of its physical plant and equipment to the number of its employees, and the logarithm of a firm’s number of employees, respectively.

We now turn to the firm-level controls. First, we include $RDSALE$, which is the logarithm

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5 Almost all industry-country pairs were either entirely characterized by cross-border acquisition or greenfield. Only about forty of over two-thousand country-industry pairs in the sample involved both cross-border acquisitions and greenfield FDI. Interestingly, firms that came to own multiple establishments in the same country-industry cell did so through multiple acquisitions. The results that obtain from estimating the same model on the raw data offer very similar results.

6 The year 1989 is a natural choice of base year because it corresponds to a benchmark survey, which covers a wider range of U.S. multinational enterprises and provides information on a larger set of firm characteristics than non-benchmark surveys.
of a firm’s R&D expenditures to its total sales. Second, we include $DIV$, which is a measure of a firm’s diversification across industries.\footnote{$DIV$ is defined as: \[
\log \left( \sum_j s_{pj}^2 \right)^{-1},
\] where $s_{pj}$ is the share of the parent firm’s sales in industry $j$, and the sum is over the eight largest industries in which the parent firm sells.} Third, to capture unobserved variation in employees’ skills, we include $WAGE$, which is the logarithm of the average wage of workers employed by the parent firm. Fourth, to quantify a parent firm’s previous experience in a foreign country $c$, we include $EXP$, which is equal to one if the parent firm owned an enterprise in country $c$ prior to the sample period, and is equal to zero otherwise. Finally, to measure the extent to which a firm tends to have affiliates that are highly integrated with the parent via intra-firm trade arrangements, we include a variable $INTRA IM$, which is the ratio of a firm’s imports from its foreign affiliates to the total value of its sales.

We include measures of three country characteristics: a host country’s level of development, its market size, and its degree of openness to international trade. To gauge a host country’s level of development in a parsimonious fashion, we include $RGDPPC$, which is the logarithm of real GDP per capita. A country’s market size is captured by $POP$, which is the logarithm of the country’s population. Finally, we include $OPEN$, which is a measure of a country’s openness to international trade (the sum of exports and imports, divided by GDP). Descriptive statistics for these country and firm characteristics are presented in table 1.

**Results.** We begin with the results for the baseline specification in which the only firm characteristic considered is the firm’s productivity. These results are shown in table 2, where the heading of each column indicates the selected measure of productivity. The first row corresponds to the coefficient estimate for the measure of productivity, and the next three rows correspond to the coefficient estimates for the three country characteristics. Note that as mentioned earlier, each of these specifications controls for fixed effect by industry of the parent firm. The standard errors for each coefficient, shown in parentheses below the coefficient estimates, are corrected for clustering by parent firm.

Looking across columns, the coefficient on the productivity measure is negative and statistically significant in each specification. In column one, the negative coefficient indicates that the parent firms with the largest U.S. sales tend to enter foreign markets through greenfield rather than acquisition. In column two, the negative coefficient indicates that firms with the highest labor productivity tend to enter through greenfield rather than through acquisition. In the third column, the coefficient on labor productivity remains negative despite the inclusion of $CAPLAB$ and $EMP$. This result suggests that the negative coefficient on labor productivity reflects greater firm level productivity rather than capital intensity, which appears to play no independent role as indicated by the small and statistically insignificant coefficient on $CAPLAB$. Interestingly, larger firms as measured by $EMP$ are also likely to enter through greenfield FDI rather than through acquisition. The results show that the firms that enter foreign markets through greenfield FDI are systematically more productive than those that enter through cross-border acquisition.

Turning to the country controls, we observe that the probability that firms enter via cross-
border acquisition is increasing in the host country’s real GDP per capita, \( RGDPPC \). Country size does not appear to play an important role in itself, as indicated by the small and statistically insignificant coefficient on \( POP \). Turning to the measure of a host country’s openness to trade, \( OPEN \), we find that the coefficient is negative and statistically significant.

Table 3 shows that the negative relationship between a firm’s propensity to favor cross-border acquisition over greenfield FDI and the firm’s productivity is robust to adding firm controls. Similarly, the coefficient on real GDP per capita, \( RGDPPC \), remains positive and statistically significant. Interestingly, the coefficient on \( INTRAIM \) is consistently negative and statistically significant: greenfield FDI appears to be more common when firms pursue a vertical integration strategy that involves shipping home intermediate inputs produced abroad.

As a final robustness check, we report in table 4 three specifications in which the fixed effects are by the industry of the affiliate rather than the industry of the parent. As shown in the first row of table 4, the coefficient estimates of the productivity variables remain negative and statistically significant. The coefficient estimate is smaller in absolute value when productivity is measured by labor productivity, but larger when measured by U.S. sales. We conclude that the relationship between a firm’s productivity and its propensity to invest abroad via greenfield FDI is robust to unobserved heterogeneity across industry of the affiliate. The same holds true for the relationship between the host country’s real GDP per capita and the firm’s choice of FDI mode.

More generally, our empirical results show that greenfield FDI and cross-border acquisitions are different: firms engaging in greenfield FDI are systematically more productive than those engaging in cross-border acquisitions, and firms are more likely to favor cross-border acquisitions over greenfield FDI, the richer and more developed is the host country.\(^8\)

### 3 The Model

We consider a model of the world economy. There are two countries, 1 and 2, indexed by \( i \). The world is populated by a unit mass of consumers with identical preferences. The representative consumer’s utility function is given by

\[
U = \ln \left[ \int_\zeta q(\zeta)^{1-\rho} x(\zeta) \rho d\zeta \right]^\frac{1}{\rho} + y, \quad \rho = \frac{\sigma - 1}{\sigma}, \quad \sigma > 1, \tag{1}
\]

where \( x(\zeta) \) is the consumption of variety \( \zeta \), \( q(\zeta) \) is the perceived quality of brand (or variety) \( \zeta \), and \( y \) the consumption of the homogeneous good. We assume that the representative consumer’s income is sufficiently large so that, in equilibrium, she will consume a positive quantity of the homogeneous good.

In each country, producers of the differentiated product face a perfectly elastic supply of labor. The wage rate in country 1 is higher than that in country 2, \( \omega_1 > \omega_2 \). This assumption can be derived as an equilibrium outcome in a general equilibrium model, where the homogeneous good is produced in both countries by perfectly competitive firms using labor, and firms

\(^8\)Our empirical results complement those of Blonigen (1997), who provides indirect evidence suggesting that greenfield FDI and cross-border acquisitions are different in nature.
in country 1 use a more efficient technology in the production of the homogeneous good than firms in country 2.\(^9\) For notational convenience, we normalize the wage in country 2 to one, \(\omega_2 \equiv 1\).

In country \(i\), there is a mass \(E_i\) of atomless producers of the differentiated good. Each firm is defined as a bundle of assets and a location of production. More formally, a firm is a triplet \((\bar{a}, q, i)\), where \(\bar{a}\) is the ability of the firm’s entrepreneur, \(q\) the quality of its (unique) brand, and \(i\) the location of production. The firm (or entrepreneur) has the property rights over its brand. A firm or entrepreneur of ability \(\bar{a}\) can produce any one unit of its brand using \(1/\bar{a}\) units of labor. The unit cost of production in country \(i\) is thus given by \(\omega_i/\bar{a}\). For notational convenience, it will be helpful to use the following (monotone) transform of the entrepreneur’s ability: \(a \equiv \bar{a}^{1/(\sigma - 1)}\). Using this transformation, the firm’s unit cost of production in country \(i\) can be rewritten as \(c_i(\zeta) = \omega_i/a(\zeta)^{1/(\sigma - 1)}\).

The initial endowment of a firm from country \(i\) is given by \((a, q, i)\). In each country, the empirical distribution function of \(q\) in the endowments of the population of firms is \(H_i\). In country \(i\), the empirical distribution function of \(a\) in the endowments of the population of firms is \(G_i\). Hence, the world distribution of entrepreneurial ability is \(G \equiv (E_1G_1 + E_2G_2)/(E_1 + E_2)\). All distribution functions are continuously differentiable and strictly increasing on \([0, \infty)\). The associated density functions are denoted by \(h\), \(g_i\), and \(g\), respectively. Our formulation allows for arbitrary correlation of \(a\)’s and \(q\)’s in the endowments of firms within each country.

An entrepreneur’s ability \(a\) is perfectly mobile internationally in that he can manage production in any one country, independently of the entrepreneur’s home country. However, each entrepreneur has a limited span of control and can manage the production of at most one brand. Transferring production of a brand to another country requires \(\phi\) units of labor in the host country. Hence, the fixed cost of moving production of a brand from country \(i\) to country \(j \neq i\) is given by \(\phi \omega_j\).

Firms (or entrepreneurs) can buy and sell their brands on a perfectly competitive international merger market. We denote the market value of a brand of quality \(q\) whose production is located in country \(i\) by \(W_i(q)\), and the shadow value of an entrepreneur with ability \(a\) by \(V(a)\).

The world’s output market is fully integrated: the differentiated product can be shipped costlessly, and there are no tariffs. Hence, the consumer price of any given variety is the same in both countries.

The timing of the model is as follows:

**Merger Stage** Firms (or entrepreneurs) buy and sell brands on the international merger market.

**Investment Stage** Firms (or entrepreneurs) decide where to locate production, potentially incurring the fixed cost \(\phi \omega_j\).

**Output Stage** Firms (or entrepreneurs) set prices to maximize profits.

\(^9\)Equivalently, we could assume that there are no wage differences, but workers in country 2 are more productive than those in country 1 when producing the differentiated good.
4 Equilibrium Assignment

In this section, we turn to the equilibrium analysis of our model. We first derive firms’ equilibrium profit as a function of the entrepreneur’s ability \( a \), the brand’s quality \( q \), and the endogenous demand level. We then study the equilibrium assignment of abilities and brand qualities and the equilibrium location of production.

**Preliminaries.** Solving the representative consumer’s utility maximization problem, we obtain the following demand for brand \( \zeta \):

\[
x(\zeta) = \frac{q(\zeta)p(\zeta)^{-\sigma}}{\int \frac{q(\zeta)p(\zeta)^{1-\sigma}}{d\zeta}},
\]

where \( p(\zeta) \) is the price of brand \( \zeta \).

Profit maximization implies that each firm charges a fixed markup, and so the price of brand \( \zeta \), when produced in country \( i \), is given by \( p(\zeta) = c_i(\zeta)/\rho \). Hence, the gross profit of a firm producing brand \( \zeta \) in country \( i \) is given by

\[
S q(\zeta)c_i(\zeta)^{1-\sigma},
\]

where the markup-adjusted residual demand level \( S \) is given by

\[
S = \left[ \sigma \int q(\zeta)c_i(\zeta)^{1-\sigma} d\zeta \right]^{-1}.
\]  

(2)

Writing gross profits as a function of entrepreneurial ability \( a \), brand quality \( q \), demand level \( S \), and location of production \( i \), we have:

\[
\Pi_i(a, q) = \begin{cases} 
\theta Saq & \text{for } i = 1, \\
Saq & \text{for } i = 2,
\end{cases}
\]

where \( \theta \equiv \omega_1^{1-\sigma} < 1 \). The parameter \( \theta \) captures the cost disadvantage of producing in country 1.

**Equilibrium Assignment and Location of Production.** We now investigate the equilibrium assignment of \( a \) and \( q \) and the equilibrium location of production as a function of the markup-adjusted residual demand level \( S \). Since firms are profit-maximizers and the international merger market is perfectly competitive, equilibrium must have the property that the allocation of brands across entrepreneurs and the location of production maximize firms’ joint profits, holding \( S \) fixed.

Recall that entrepreneurs are perfectly mobile internationally: they can manage production in any one country without incurring any additional cost. In contrast, brands are not perfectly mobile internationally: to move production of a brand that originated in country \( i \) to country \( j \neq i \), a fixed cost of \( \phi \omega_j \) has to be incurred. Hence, the country of origin matters for brands but not for entrepreneurs.

The equilibrium allocation can therefore be characterized as follows. For any given brand of quality \( q \) that originated in country \( i \):
1. What is the equilibrium location of production of that brand?

2. What entrepreneurial type \( a \) will in equilibrium manage production of that brand?

Regarding the equilibrium locations of brands, two immediate observations can be made. First, since entrepreneurs are perfectly mobile and country 2 has a cost advantage in production, no brand that originated in country 2 will be produced in country 1. Second, there must exist a threshold quality \( \overline{q} \) such that a brand of quality \( q \) that originated in country 1 will be produced in country 2 if and only if \( q > \overline{q} \). To see this, suppose otherwise. Then, there exists some \( \epsilon > 0 \), for any given (endogenous) threshold \( \overline{q} \), whose brands \( q' \) and \( q'' < q' \) originated in country 1, and firm \( (a', q') \) locates production in country 1, while firm \( (a'', q'') \) locates in country 2. The resulting joint profit of the two firms is 
\[
S[\theta a'q' + a''q''] - \phi.
\]
However, this cannot be an equilibrium. If the better of the two entrepreneurs, \( \max\{a', a''\} \), purchases the better brand \( q' \) and locates production in country 2, while the other entrepreneur purchases brand \( q'' \) and locates production in country 1, then the two firms’ joint profit is given by 
\[
S[\theta \min\{a', a''\}q'' + \max\{a', a''\}q'] - \phi,
\]
which is greater than the joint profit in the candidate equilibrium.

We now turn to the equilibrium assignment of entrepreneurs and brands. Let \( a_i(q) \) denote the ability of the entrepreneur who will, in equilibrium, manage production of brand \( q \) in country \( i \), for any given (endogenous) threshold \( \overline{q} \). It is straightforward to show that \( a_i(\cdot) \) is single-valued (i.e., it is a function) and continuous. However, note that \( a_1(\cdot) \) is empty-valued for \( q > \overline{q} \) since the production of all such brands occurs in country 2. Furthermore, supermodularity of the profit function with respect to \( a \) and \( q \) implies that \( a_i(q) \) is strictly increasing in \( q \). That is, within each country, there is positive assortative matching between managerial ability and brand quality: the better is the quality of a brand located in country \( i \), the more able is the entrepreneur who manages the brand.

Since entrepreneurs are perfectly mobile internationally, there is a no-arbitrage condition which links \( a_1(\cdot) \) and \( a_2(\cdot) \): 
\[
a_1(q) = a_2(\theta q) \quad \text{for all } q \leq \overline{q}.
\] (3)
To see this, suppose otherwise. Then, there exists some \( q \leq \overline{q} \) such that either \( a_1(q) > a_2(\theta q) \), or else the reverse inequality holds. Suppose \( a_1(q) > a_2(\theta q) \) (the argument is analogous for the reverse inequality). Since \( a_2(\cdot) \) is continuous and increasing, there must exist a brand of quality \( \theta q + \epsilon > \theta q \), which is produced in country 2, and for which \( a' \equiv a_1(q) > a_2(\theta q + \epsilon) \equiv a'' \). However, joint profits can then be increased if production of brand \( q \) in country 1 is managed by entrepreneurial type \( a'' \), while production of \( \theta q + \epsilon \) in country 2 is managed by \( a' > a'' \).

We are now in the position to derive \( a_i(q) \). Since all brands of quality \( q > \overline{q} \) will be produced in country 2, independently of their country of origin, and since there is positive assortative matching between \( a \) and \( q \), we have
\[
(E_1 + E_2)[1 - G(a_2(q))] = (E_1 + E_2)[1 - H(q)] \quad \text{for } q \geq \overline{q}.
\]
The term on the l.h.s. represents the mass of entrepreneurs with ability of at least \( a_2(q) \), while on the r.h.s. is the mass of brands of quality \( q \) and higher. Solving for \( a_2(q) \) yields
\[
a_2(q) = G^{-1}(H(q)) \quad \text{for } q \geq \overline{q}.
\] (4)
From the no-arbitrage condition (3), \( a_1(\overline{q}) = a_2(\theta \overline{q}) < a_2(\overline{q}) \). Hence, all entrepreneurs of ability \( a_2(\theta \overline{q}) \leq a \leq a_2(\overline{q}) \) will manage production in country 2. We thus have

\[
(E_1 + E_2) [G(a_2(q)) - G(a_2(q))] = E_2 [H(\overline{q}) - H(q)] \text{ for } q \in [\theta \overline{q}, \overline{q}].
\]

Observing that \( G(a_2(q)) = H(\overline{q}) \), we obtain

\[
a_2(q) = G^{-1} \left( \frac{E_1 H(q) + E_2 H(q)}{E_1 + E_2} \right) \text{ for } q \in [\theta \overline{q}, \overline{q}].
\]

Consider the allocation of brands of quality \( q < \theta \overline{q} \), located in country 2. We have

\[
(E_1 + E_2) G(a_2(q)) = E_1 H(q/\theta) + E_2 H(q) \text{ for } q < \theta \overline{q}.
\]

The term on the l.h.s. represents the mass of entrepreneurs from both countries who have ability less than or equal to \( a_2(q) \). The second term on the r.h.s. is the mass of brands of quality \( q \) or less that locate (and originate) in country 2. Since \( a_2(q) = a_1(q/\theta) \), the first term on the r.h.s. represents the mass of brands that locate (and originate) in country 1 and that are managed, in equilibrium, by entrepreneurs of ability \( a_2(q) \) or less. Solving the equation for \( a_2(q) \) yields

\[
a_2(q) = G^{-1} \left( \frac{E_1 H(q/\theta) + E_2 H(q)}{E_1 + E_2} \right) \text{ for } q \leq \theta \overline{q}.
\]

Finally, using the no-arbitrage condition (3), we obtain

\[
a_1(q) = G^{-1} \left( \frac{E_1 H(q) + E_2 H(\theta q)}{E_1 + E_2} \right) \text{ for } q \leq \overline{q}.
\]

Summarizing, the function \( a_2(\cdot) \) is defined, over the relevant domains, by equations (4), (5), and (6), while the function \( a_1(\cdot) \), which is only defined for \( 0 \leq q \leq \overline{q} \), is given by (7). Note that both functions are continuous (wherever defined). Moreover, \( a_2(\cdot) \) is differentiable except at \( \theta \overline{q} \) and \( \overline{q} \), while \( a_1(\cdot) \) is differentiable for \( q < \overline{q} \). Observe also that \( a_2(\cdot) \) depends on \( \overline{q} \); we will later analyze how this function changes with \( \overline{q} \).

Equilibrium Price Schedules. Having analyzed the equilibrium assignment and location of production (as a function of \( S \)), we can now determine the equilibrium price schedules for brand qualities and entrepreneurial abilities on the international merger market, for any given markup-adjusted residual demand level \( S \).

Consider first the equilibrium gross profit \( \Pi_2(a_2(q), q) \) of a firm with brand quality \( q \) and entrepreneurial ability \( a_2(q) \), whose production is located in country 2. The gross profit can be written as

\[
\Pi_2(a_2(q), q) = \int_0^q \frac{\partial \Pi_2(a_2(z), z)}{\partial a} \frac{\partial a_2(z)}{\partial z} dz + \int_0^q \frac{\partial \Pi_2(a_2(z), z)}{\partial z} dz.
\]

On the other hand, the return of an entrepreneur of ability \( a_2(q) \) is the difference between the firm’s gross profit and the equilibrium price of brand \( q \), i.e.,

\[
V(a_2(q)) = \Pi_2(a_2(q), q) - W_2(q).
\]
Hence, we can decompose the gross profit as follows:

\[
\Pi_2(a_2(q), q) = V(a_2(q)) + W_2(q) = \int_0^q V'(a_2(z)) \frac{\partial a_2}{\partial z} dz + \int_0^q W_2'(z) dz.
\]

This decomposition implies that

\[
\frac{\partial \Pi_2(a_2(z), z)}{\partial a} = V'(a_2(z)) \quad \text{and} \quad \frac{\partial \Pi_2(a_2(z), z)}{\partial z} = W_2'(z).
\]

Since \(\Pi_2(a_2(q), q) = Sa_2(q)q\), the equilibrium price schedules can be written as

\[
W_2(q) = \int_0^q \frac{\partial \Pi_2(a_2(z), z)}{\partial z} dz = S \int_0^q a_2(z) dz,
\]

and

\[
V(a_2(q)) = S \left[ a_2(q)q - \int_0^q a_2(z) dz \right].
\]

Consider now the equilibrium price schedule for brands created in country 1. Recall that when brands are traded on the international merger market, the location of production has not yet been determined, and so no fixed costs have been incurred. Following the same logic as above, we can establish that

\[
W_1(q) = \theta S \int_0^q a_1(z) dz = W_2(\theta q) \quad \text{for} \quad q \leq \overline{q}.
\]

The second equality can be derived by rewriting the integral, using the no-arbitrage condition (3). Furthermore, we have

\[
W_1(q) = W_2(q) - \phi \quad \text{for} \quad q \geq \overline{q}
\]

since, in equilibrium, the production of brands of this quality will be located in country 2, which requires incurring the fixed cost \(\phi\).

From equations (9) and (10), it follows that

\[
W_2(\theta \overline{q}) = W_2(\overline{q}) - \phi.
\]

If a brand of quality \(\overline{q}\) that originated in country 1 is produced in country 1, it will be managed by an entrepreneur of ability \(a_1(\overline{q}) = a_2(\theta \overline{q})\), and its value is thus \(W_2(\theta \overline{q})\). On the other hand, if a brand of the same quality and origin is produced in country 2, it will be managed by an entrepreneur of ability \(a_2(\overline{q})\). Because moving production requires a fixed cost of \(\phi\), the brand’s value is equal to the value of a brand of the same quality that originated in country 2, minus
the fixed cost. In equilibrium, the two usages of the threshold brand $\overline{q}$ must generate the same value. Using (8), equation (11) can be rewritten as

$$S \int_{0}^{\overline{q}} a_2(q) dq = \phi.$$  \hspace{1cm} (12)

The l.h.s. of this equation is the profit increase from a relocation of production of a brand of quality $\overline{q}$ (originating in country 1) to country 2, taking into account that the equilibrium assignment of entrepreneurs to brands depends on the location of production. From the viewpoint of maximizing profits (holding $S$ fixed), moving brand $\overline{q}$ from country 1 to country 2 implies that an entrepreneur of ability $a_1(\overline{q}) = a_2(\theta \overline{q})$ is freed up in country 1 to manage production of brand $\theta \overline{q}$ in country 2, which in turn allows a re-assignment of entrepreneurs to brands in country 2: all brands of quality between $\theta \overline{q}$ and $\overline{q}$ will now be managed by more able entrepreneurs, which generates additional profit. On the r.h.s. of equation (12) is the cost of such a relocation of production.

The Markup-Adjusted Residual Demand Level. So far, we have derived the equilibrium assignment and location of production for a given markup-adjust residual demand level $S$. However, $S$ is endogenous and determined jointly with the (endogenous) threshold quality $\overline{q}$.

From equation (2) and the equilibrium assignment of entrepreneurs to brands derived above, the markup-adjusted residual demand level is given by

$$S = \sigma^{-1} \left[ E_1 \theta \int_{0}^{\overline{q}} qa_1(q) dH(q) + E_2 \int_{0}^{\overline{q}} qa_2(q) dH(q) \right]^{-1} \left[ E_1 \phi \int_{0}^{\overline{q}} qa_2(q) dH(q) \right] + (E_1 + E_2) \int_{\overline{q}}^{\infty} qa_2(q) dH(q).$$  \hspace{1cm} (13)

Combining this equation with the equilibrium condition for $\overline{q}$, equation (12), we can write the equilibrium threshold quality as a function of the exogenous variables $\theta$, $\sigma$, $\phi$, $\omega_2$, $E_1$, and $E_2$ (as well as the distribution functions $G$ and $H$):

$$0 = \sigma \phi \left[ E_1 \theta \int_{0}^{\overline{q}} qa_1(q) dH(q) + E_2 \int_{0}^{\overline{q}} qa_2(q) dH(q) \right] - \left[ E_1 \phi \int_{0}^{\overline{q}} qa_2(q) dH(q) \right] + (E_1 + E_2) \int_{\overline{q}}^{\infty} qa_2(q) dH(q) - \int_{0}^{\overline{q}} a_2(q) dq.$$  \hspace{1cm} (14)

It can be established that the r.h.s. of (14) is continuous and strictly decreasing in $\overline{q}$. Furthermore, the r.h.s. is strictly positive for $\overline{q} = 0$, and becomes negative for $\overline{q}$ sufficiently large.\(^{10}\) Hence, there exists a unique threshold quality $\overline{q}$, implicitly defined by equation (14).

Endogenous Cross-Country Differences in the Distribution of Firm Efficiencies. The equilibrium assignment of entrepreneurs to brands and the equilibrium location of production have important consequences for cross-country differences in the distribution of firm efficiencies. In

\(^{10}\) As $\overline{q} \to \infty$, the term in brackets remains bounded, while the second term on the r.h.s. tends to negative infinity.
our framework, it is natural to define the efficiency of a firm of type \{a, q, i\} at the output stage by \( \varphi(\{a, q, i\}) = aq \) since the firm’s gross profit is proportional to \( aq \).

As we will show, the following two observations imply that the distribution of firm efficiencies is shifted towards more efficient firms in country 2 as compared to country 1. First, in equilibrium, the production of all of the best brands will be located in country 2. Second, in equilibrium, a brand of any given quality \( q \) will be managed by a more able entrepreneur in country 2 than in country 1: \( a_2(q) > a_1(q) \).

**Proposition 1** In equilibrium, the distribution of firm efficiencies in country 2 first-order stochastically dominates that in country 1.

**Proof.** Let \( \lambda_i(\varphi) \) denote the fraction of firms producing in country \( i \) that are of efficiency less than or equal to \( \varphi \). We need to show that \( \lambda_1(\varphi) > \lambda_2(\varphi) \) for all \( \varphi > 0 \).

For \( \varphi \geq qa_1(\overline{\varphi}) \), we have

\[
\lambda_1(\varphi) = 1 > \lambda_2(\varphi).
\]

Consider now \( 0 < \varphi < qa_1(\overline{\varphi}) \), and let \( q_i(\varphi) \) be such that \( \varphi = q_i(\varphi)a_i(q_i(\varphi)) \), i.e., \( q_i(\varphi) \) is the quality of the brand that will, in equilibrium, be produced by a firm of efficiency \( \varphi \) in country \( i \). We have

\[
\lambda_1(\varphi) = \frac{E_1H(q_1(\varphi))}{E_1H(\overline{\varphi})} > \frac{E_1H(\overline{\varphi})}{1 + (E_1/E_2)[1 - H(\overline{\varphi})]} > \frac{E_2H(q_2(\varphi))}{E_2 + E_1[1 - H(\overline{\varphi})]} \equiv \lambda_2(\varphi),
\]

where the second inequality follows from the observation that \( q_1(\varphi) > q_2(\varphi) \).

In our model, underlying differences in factor prices across countries induce differences in the distributions of firm efficiencies through a reassignment of entrepreneurs and brands. This result has important implications for empirical work. As is widely known, efficiency levels are observed to be different across countries. These differences have often been attributed to Ricardian technology differences. In contrast, in our model, there are no intrinsic technology differences between countries in the differentiated goods sector, and yet countries have apparent efficiency differences. Alternatively, if we were to interpret \( \theta \) as representing underlying productivity differences between countries, then any such underlying productivity difference would be magnified by the reassignment of brands and entrepreneurs across countries.\(^{11}\)

\(^{11}\)In Nocke (2003), entrepreneurs of varying abilities sort into markets of different size, inducing efficiency differences across otherwise identical markets. However, the sorting mechanism is rather different: in Nocke’s model, the sorting result is driven by product market competition, while in our paper it is caused by underlying factor price differences.
5 Trade and FDI Flows

In the previous section, we derived the equilibrium assignment of entrepreneurs to brands and the equilibrium location of production. What still needs to be analyzed is the implied equilibrium pattern of trade and FDI. In this section, we interpret the assignment of entrepreneurs to brands and the location of production in terms of choice of FDI mode. We then present two key results. First, all greenfield FDI is one-way: from the high cost to the low cost location, while cross-border acquisitions occur in both directions. Second, in the limit as factor price differences between countries vanish, all FDI takes the form of cross-border acquisitions.

Types of FDI. In our model, it is natural to assume that the identity of a firm is linked to its entrepreneur. In this sense, it will be the entrepreneurs that buy or sell brands, rather than the reverse. Greenfield FDI from country $i$ to country $j$ occurs whenever an entrepreneur from country $i$ transfers production of a brand from country $i$ to country $j$. Cross-border acquisition from country $i$ to country $j$ occurs whenever an entrepreneur from country $i$ purchases a brand from country $j$, independently of where this brand will be produced. Two types of cross-border acquisitions are possible, dependent on whether the acquired brand will be produced in its country of origin, or whether local production will be closed down and transferred to the entrepreneur’s home country.

Equilibrium Selection. Both the assignment of entrepreneurial types to brand qualities and the location of production by brand quality are uniquely pinned down in equilibrium. However, in the absence of any mobility costs for entrepreneurs, entrepreneurs of any given ability but originating in different countries are perfect substitutes. Consequently, there is indeterminacy in the equilibrium gross flows of FDI. Since the assumption of no frictions in the international merger market may be viewed as a limiting case where such frictions become small, we henceforth confine attention to the equilibrium pattern of FDI that minimizes the volume of cross-border acquisitions.

Composition of International Commerce. We are now in the position to provide a first characterization of trade and FDI flows. Since no brands originating in country 2 are moved to country 1, while all brands from country 1 that are of quality $q > \bar{q}$ are transferred to country 2, all greenfield FDI is one-way, namely from country 1 to country 2. Moreover, since we restrict attention to the equilibrium pattern of FDI that minimizes the volume of cross-border acquisitions, all brands of quality $q > \bar{q}$ that originated in country 1 will be moved to country 2 as part of greenfield FDI, provided the country-1 supply of entrepreneurs of ability $a_2(q)$ is at least as large as the country-1 endowments of brands of quality $q$. Otherwise, any remaining brands of that quality will be acquired by entrepreneurs from country 2, and their production will be moved to country 2. In contrast, all brands that are of quality $q < \bar{q}$ from country 1, and of any quality $q$ from country 2, will be locally produced. These brands will be acquired by a local entrepreneur of ability $a_i(q)$, or else if the local supply of such entrepreneurs is too small, by a foreign entrepreneur.

More formally, let $\psi_1(q)$ denote the ratio between the number of entrepreneurs, originating in country 1, who in equilibrium will be assigned to a brand of quality $q$, and the number of brands of that quality originating in country 1. If $\psi_1(q) < 1$, then a fraction $1 - \psi_1(q)$ of these brands must be acquired by foreign firms (entrepreneurs). A brand of quality $q < \bar{q}$ will, in
equilibrium, be managed by an entrepreneur of ability \(a_1(q)\), and so we have

\[
\psi_1(q) = \lim_{\Delta \to 0} \frac{E_1 [G_1(a_1(q + \Delta)) - G_1(a_1(q))]}{E_1 [H(q + \Delta) - H(q)]} = \frac{g_1(a_1(q))}{h(q)} a_1'(q),
\]

for \(q < \bar{q}\). A brand of quality \(q > \bar{q}\), on the other hand, will be managed by an entrepreneur of ability \(a_2(q)\), and so

\[
\psi_1(q) = \lim_{\Delta \to 0} \frac{E_1 [G_1(a_2(q + \Delta)) - G_1(a_2(q))]}{E_1 [H(q + \Delta) - H(q)]} = \frac{g_1(a_2(q))}{h(q)} a_2'(q),
\]

for \(q > \bar{q}\). Using equations (4) and (7), we can rewrite \(\psi_1(q)\) as

\[
\psi_1(q) = \begin{cases} 
\frac{g_1(a_1(q))}{g(a_1(q))} \left[ \frac{E_1}{E_1 + E_2} + \frac{\theta E_2}{E_1 + E_2} \frac{h(q)}{h(q)} \right] & \text{if } q < \bar{q}, \\
\frac{g_1(a_2(q))}{g(a_2(q))} & \text{otherwise}.
\end{cases}
\]  

(15)

Similarly, let \(\psi_2(q)\) denote the ratio between the number of entrepreneurs of ability \(a_2(q)\), originating in country 2, and the number of brands of quality \(q\) originating in country 2. If \(\psi_2(q) < 1\), then a fraction \(1 - \psi_2(q)\) of these brands must be acquired by foreign firms (entrepreneurs). Following the same steps as above, we establish that

\[
\psi_2(q) = \begin{cases} 
\frac{g_2(a_2(q))}{g(a_2(q))} \left[ \frac{E_2}{E_1 + E_2} + \frac{\theta E_2}{E_1 + E_2} \frac{h(q)}{h(q)} \right] & \text{if } q < \theta \bar{q}, \\
\frac{g_2(a_2(q))}{g(a_2(q))} & \text{if } q \in (\theta \bar{q}, \bar{q}), \\
\frac{g_2(a_2(q))}{g(a_2(q))} & \text{if } q \geq \bar{q}.
\end{cases}
\]  

(16)

Comparing equations (15) and (16), we observe that for \(q < \bar{q}\),

\[
\psi_1(q) < 1 \iff \frac{\theta h(q)}{h(q)} < \frac{g_2(a_1(q))}{g(a_1(q))} \iff \psi_2(\theta q) > 1.
\]

That is, whenever country 1 has an insufficient number of entrepreneurs of ability \(a_1(q) = a_2(\theta q)\) to manage the domestic brands of quality \(q\), there is an excess number of entrepreneurs of that quality in country 2 to manage the domestic brands of quality \(\theta q\).

Using the functions \(\psi_1\) and \(\psi_2\), we can derive aggregate statistics of FDI flows. Let \(f_i\) and \(m_i\) denote the fractions of entrepreneurs (firms) from country \(i\) who will engage in greenfield FDI and cross-border acquisitions, respectively. Since all greenfield FDI is directed toward the country with the comparative advantage in production, \(f_2 = 0\). On the other hand,

\[
f_1 = \int_{\bar{q}}^\infty \min \{\psi_1(q), 1\} \, dH(q)
\]  

(17)
since a fraction \( \min \{ \psi_1(q), 1 \} \) of a brand of quality \( q > \overline{q} \) originating in country 1 will be transferred to country 2 as part of greenfield FDI (while the remaining fraction \( \max \{ 1 - \psi_1(q), 0 \} \) will be acquired by entrepreneurs from country 2 and then moved).

As regards cross-border acquisitions, we have

\[
m_1 = \frac{E_2}{E_1} \int_{0}^{\infty} \max \{ 1 - \psi_2(q), 0 \} dH(q).
\]

To see this, note that if \( \psi_2(q) < 1 \), there is an insufficient number of entrepreneurs from country 2 that have the “right” ability to manage production of quality-\( q \) brands in country 2, and so a fraction \( 1 - \psi_2(q) \) will to be acquired by entrepreneurs from country 1. Similarly, we have

\[
m_2 = \frac{E_1}{E_2} \int_{0}^{\infty} \max \{ 1 - \psi_1(q), 0 \} dH(q).
\]

We can now make two important observations. First, the flows of cross-border acquisitions will be balanced in equilibrium,

\[ E_1 m_1 = E_2 m_2. \]

Balancedness obtains since, in each country, the mass of entrepreneurs is equal to the mass of brands, both before the merger market opens as well as after the merger market closes. Moreover, each greenfield investment involves one entrepreneur and one brand from the same country. Second, all entrepreneurs from country 1 who are of ability \( a \in (a_2(\theta \overline{q}), a_2(\overline{q})) \) will be engaged in cross-border acquisitions in country 2. Hence, \( m_1 = (E_2/E_1)m_2 > 0 \). In fact, it can easily be shown that \( \psi_2(q) < 1 \) for \( q \in (\theta \overline{q}, \overline{q}) \). More generally, for (almost) any \( q \), we generically have \( \psi_i(q) \neq 1 \).

We summarize our results in the following proposition.

**Proposition 2** In equilibrium, greenfield FDI and cross-border acquisitions co-exist. All greenfield FDI is one-way: from country 1 to country 2, but not in the reverse direction. In contrast, cross-border acquisitions are two-way: from country 1 to country 2, and from country 2 to country 1.

Existing models of vertical FDI (e.g., Helpman, 1984) predict that, at any given production stage, all FDI flows are one-way: the only receiving country is the one that has a comparative advantage in that stage of production. Yet, there is overwhelming empirical evidence showing that FDI flows are generally two-way. In light of this stylized fact, trade theorists have relied on models with transport costs to generate two-way FDI. As proposition 2 shows, transport costs are not necessary to generate this stylized fact.

There is ample evidence that many governments are wary of foreign acquisitions of domestic establishments that result in the closure of local production. Our model can indeed generate such FDI. The measure of firms involved in such FDI is

\[ E_1 \int_{\overline{q}}^{\infty} \max \{ 1 - \psi_1(q), 0 \} dH(q), \]
which is positive if and only if $g_1(a) < g_2(a)$ for some $a > a_2(\overline{q})$. Interestingly, if foreign acquisitions result in the closure of local production, they involve the better brands (of quality exceeding $\overline{q}$) from country 1.

*Vanishing Factor Price Differences.* As our empirical analysis in section 2 has revealed, cross-border acquisitions are the dominant mode of FDI between the richest and most developed countries (where, arguably, factor price differences are not very large). In contrast, a much larger fraction of FDI flows from the rich and developed countries to the poor and developing countries (where, arguably, factor price differences play an important role) involve greenfield acquisitions.

To explain these findings within our model, we therefore analyze the composition of FDI in the limit as factor price differences become small, i.e., as $\theta \to 1$. An immediate observation is that the quality threshold $\overline{q} \to \infty$ as $\theta \to 1$. To see this, suppose otherwise that $\overline{q}$ is bounded below, independently of $\theta$. But then, the r.h.s. of equation (14) is strictly positive for $\theta$ sufficiently close to one, while the l.h.s. is identical to zero; a contradiction. Consequently, greenfield FDI disappears as factor price differences become small: $f_1 \to 0$ as $\theta \to 1$. Next, as can be seen from equation (16), for any $q$,

$$\psi_2(q) \to \frac{g_2(a_2(q))}{g(a_2(q))} \text{ as } \theta \to 1.$$ 

However, generically, we have $g_2(a) \neq g(a)$ for (almost) any $a$. Hence, $m_1$ and $m_2$ are bounded away from zero, even as $\theta \to 1$. We therefore obtain the following key result.

**Proposition 3** There always exist cross-border acquisitions in both directions, independently of factor price differences. In contrast, greenfield FDI disappears in the limit as factor price differences vanish. Hence, as $\theta \to 1$, all FDI takes the form of cross-border acquisitions.

What this proposition highlights is that there are two reasons why cross-border acquisitions, but only one reason for the existence of greenfield FDI. In our model, greenfield FDI only occurs because firms want to exploit factor price differences by moving brands from a high cost to a low cost location. In contrast, cross-border acquisitions not only exist because of factor price differences, but also because the distribution of entrepreneurial abilities (or, more generally, of firm-specific assets) varies from one country to another. This result is reminiscent of Grossman and Maggi (2000), where trade between countries occurs because of differences in the distributions of workers’ talent.

### 6 Firm Efficiency and Choice of FDI Mode

In this section, we further explore the mapping from a firm’s efficiency to its choice of FDI mode. For this purpose, we impose additional structure on the distributions of entrepreneurial abilities. We then obtain another key result: firms that engage in greenfield FDI are systematically more efficient than those that engage in cross-border acquisitions. Moreover, we show that, under some modest regularity condition on the distribution of brand qualities, the probability that an entrepreneur from country 1 engages in FDI is weakly increasing in the entrepreneur’s ability.
Efficiency Differences: Greenfield FDI vs. Cross-Border Acquisitions. As our empirical analysis in section 2 has revealed, U.S. firms engaging in greenfield FDI are systematically more efficient than U.S. firms engaging in cross-border acquisitions. Our model generates this result under a variety of distributional assumptions. A natural restriction on the distribution of entrepreneurial abilities that allows us to obtain this result is the following symmetry condition.

(C1) The distributions of entrepreneurial abilities are the same in both countries: $G_1 \equiv G_2$.

Given this symmetry in entrepreneurial abilities across countries, all FDI is motivated by factor price differences. As can be seen from equations (15) and (16), (C1) implies that $\psi_1(q) = \psi_2(q) = 1$ for all $q \geq \bar{q}$. Hence, all cross-border acquisitions involve brands of quality $q < \bar{q}$, while all greenfield FDI still involves only brands of quality $q > \bar{q}$. Positive assortative matching between $a$ and $q$ in each country then implies the following proposition.\(^{12}\)

**Proposition 4** Any firm engaging in greenfield FDI is more efficient than any firm engaging in cross-border acquisitions.

Through the lens of this proposition, it may become apparent why the governments of many countries appear to favor greenfield FDI over cross-border acquisitions. Policymakers may perceive two important differences between the two FDI modes. First, greenfield FDI involves the creation of new establishments. Second, greenfield FDI involves the best foreign firms, and therefore a large number of workers.

Efficiency Differences: Cross-Border Acquisitions vs. Domestic Production. To further tighten our predictions on the efficiency differences between firms engaging in different modes of serving the world market, we impose a mild regularity condition on the distribution of brand qualities.

(C2) The elasticity of the density function $h$,

\[
\frac{qh'(q)}{h(q)}
\]

is strictly decreasing in $q$.

It can easily be verified that condition (C2) is satisfied by a number of standard distributions, e.g., by the two-parameter family of Weibull distributions, $H(q) = 1 - e^{-(q/\beta)}$, $\alpha > 0$, $\beta > 0$ (which includes the exponential distribution as a special case with $\alpha = 1$) and the two-parameter family of Gamma distributions (which includes the chi-squared distribution as a special case). Henceforth, we will assume that both distributional conditions, (C1) and (C2), hold.

\(^{12}\)If we were to relax the symmetry condition (C1), we would still obtain that firms engaging in greenfield FDI are, on average, more efficient than firms engaging in cross-border acquisitions. To violate this weaker prediction, one would need a very strong departure from symmetry, and in a particular direction, namely that one country has a much larger supply of the very best entrepreneurs than another.
(C1) implies that $\psi_1(0) < 1 < \psi_2(0)$. Moreover, (C1) and (C2) imply that $\psi_1(\cdot)$ is strictly increasing on $[0, \overline{q}]$, and $\psi_2(\cdot)$ is strictly decreasing on $[0, \theta \overline{q}]$, has a downward jump at $\theta \overline{q}$, and is constant on $[\theta \overline{q}, \overline{q}]$. It will prove useful to define a second threshold brand quality, $\hat{q}$. If $\psi_1(\hat{q}) = 1$ for some $\hat{q} < \overline{q}$, we then have $\psi_1(q) < 1$ and $\psi_2(\theta q) > 1$ for all $q < \hat{q}$. Moreover, $\psi_1(q) > 1$ and $\psi_2(q) < 1$ for all $\hat{q} < q < \overline{q}$. Formally, let

$$\hat{q} = \begin{cases} \psi^{-1}_1(1) & \text{if } \psi_1(\overline{q}) > 1, \\ \overline{q} & \text{otherwise.} \end{cases}$$

(20)

Using this threshold $\hat{q}$ and equations (17) to (19), we can summarize the relationship between firm efficiency and FDI mode choice as follows.

**Proposition 5** Consider the mapping from entrepreneurial ability to mode of FDI. For entrepreneurs of ability $a < a_2(\theta \overline{q}) = a_1(\overline{q})$, all FDI involves cross-border acquisitions in country 1. For entrepreneurs of ability $a \in (a_2(\theta \overline{q}), a_2(\overline{q}))$, all FDI involves cross-border acquisitions in country 2. For entrepreneurs of ability $a > a_2(\overline{q})$, all FDI involves greenfield FDI in country 2.

Consider an entrepreneur of ability $a$ from country 1. If $a \leq a_1(\overline{q}) = a_2(\theta \overline{q})$, he will not engage in FDI. If $a > a_1(\overline{q}) = a_2(\theta \overline{q})$, he will engage in FDI with probability one, namely in cross-border acquisitions if $a \in (a_2(\theta \overline{q}), a_2(\overline{q}))$, and in greenfield FDI if $a > a_2(\overline{q})$. An entrepreneur of ability $a \in (a_2(\theta \overline{q}), a_2(\theta \overline{q}))$ will, with positive probability, acquire a brand in country 2. The probability that a country-2 brand of quality $q \in (\theta \overline{q}, \theta \overline{q})$ will be acquired by a foreign entrepreneur is $1 - \psi_2(q) \geq 0$, and is strictly increasing in $q$. Positive assortative matching between $a$ and $q$ then implies that the probability that a country-1 entrepreneur of ability $a \in (a_2(\theta \overline{q}), a_2(\theta \overline{q}))$ engages in cross-border acquisitions is strictly increasing in $a$.

Consider now an entrepreneur of ability $a$ from country 2. If $a \geq a_2(\theta \overline{q}) = a_1(\overline{q})$, he will not engage in FDI. On the other hand, if $a < a_1(\overline{q})$, he will engage in cross-border acquisitions with positive probability. The probability that a country-1 brand of quality $q < \hat{q}$ will be acquired by an entrepreneur from country 2 is $1 - \psi_1(q) \geq 0$, and is strictly decreasing in $q$. Positive assortative matching then implies that the probability that a country-2 entrepreneur of ability $a < a_1(\overline{q})$ engages in cross-border acquisitions is strictly decreasing in $a$.

We thus obtain the following monotonicity result.

**Proposition 6** The probability that an entrepreneur from country 1 engages in FDI is weakly increasing in his ability $a$, while the opposite is true for entrepreneurs from country 2.

Proposition 6 implies, in particular, that in the high-cost country, firms engaging in cross-border acquisitions are, on average, more efficient than firms producing domestically. In the low-cost country, the reverse holds.

## 7 Comparative Statics

In this section, we further explore the workings of our model. We generate a number of additional predictions by analyzing the effects of changing various exogenous variables on the equilibrium assignment and location of production, and the aggregate statistics of FDI.
Throughout this section, we assume that conditions (C1) and (C2) hold. The aggregate statistics of FDI, (17) to (19), then simplify to

\[ m_1 = \frac{E_2}{E_1} m_2 = \frac{E_2}{E_1 + E_2} [H(\bar{q}) - H(\theta \bar{q})], \]

and

\[ f_1 = 1 - H(\bar{q}). \]

The Fixed Cost of Greenfield FDI. We now want to explore the effects of changing the fixed cost \( \phi \) of moving a brand from one country to another. Intuitively, one would expect that an increase in \( \phi \) raises the threshold brand quality \( \bar{q} \), and hence reduces the share \( f_1 \) of entrepreneurs from country 1 engaging in greenfield FDI in country 2. Indeed, this can easily be established using equation (14). Further, \( \bar{q} \to 0 \) as \( \phi \) becomes small, and \( \bar{q} \to \infty \) as \( \phi \) becomes large. Next, note that if \( \bar{q} < \bar{q} \), \( \bar{q} \) is implicitly defined by \( \theta h(\theta \bar{q})/h(\bar{q}) = 1 \), and hence (locally) independent of \( \phi \); otherwise \( \bar{q} = \bar{q} \), and so \( \bar{q} \) is strictly increasing in \( \phi \). We thus have the following lemma.

**Lemma 1** The threshold \( \bar{q} \) is strictly increasing in \( \phi \), \( \bar{q} \to 0 \) as \( \phi \to 0 \), and \( \bar{q} \to \infty \) as \( \phi \to \infty \). Further, if \( \bar{q} < \bar{q} \), then \( \bar{q} \) is (locally) independent of \( \phi \). Hence, there exists a unique \( \bar{\phi} > 0 \) such that \( \bar{q} < \bar{q} \) for all \( \phi > \bar{\phi} \), and \( \bar{q} = \bar{q} \) for all \( \phi \leq \bar{\phi} \).

Since \( \bar{q} \) is strictly increasing in \( \phi \), it follows immediately from equation (22) that the fraction \( f_1 \) of entrepreneurs from country 1 engaging in greenfield FDI is decreasing in \( \phi \). The effect of \( \phi \) on the cross-border acquisition volume, however, depends on whether or not \( \phi > \bar{\phi} \): as can be seen from equation (21), \( m_1 \) nor \( m_2 \) are increasing in \( \bar{q} \) and do not directly depend on \( \phi \). However, as the lemma states, \( \bar{q} \) is (locally) independent of \( \phi \) for \( \phi > \bar{\phi} \), and (locally) increasing in \( \phi \) for \( \phi < \bar{\phi} \). We summarize these results in the following proposition.

**Proposition 7** A small increase in the fixed cost \( \phi \) of greenfield FDI, \( d\phi > 0 \), has the following effects:

\[ df_1 < 0, \quad dm_1 = \frac{E_2}{E_1} dm_2 \begin{cases} > 0 & \text{if } \phi < \bar{\phi} \\ = 0 & \text{otherwise.} \end{cases} \]

This proposition shows that the total number of cross-border acquisitions can be independent of the cost and volume of greenfield FDI, namely whenever the fixed cost \( \phi \) is sufficiently large (and the volume of greenfield FDI small). However, even in this case, the composition of cross-border acquisitions from country 1 to country 2 is not independent of \( \phi \) in the sense that a change in \( \phi \) affects the set of entrepreneurs from country 1 who will engage in cross-border mergers.

**Country Characteristics.** We now want to investigate the effects on the equilibrium of varying country characteristics: the factor price differential, as measured by \( \theta \), and the numbers of entrepreneurs in each country, \( E_1 \) and \( E_2 \). For simplicity, we will confine attention to the case \( \phi > \bar{\phi} \).

Consider first an increase in \( \theta \), i.e., a reduction in the factor price difference between the two countries. Under condition (C1), FDI is ultimately driven by factor price differences. Hence,
one would expect the volume of FDI to decrease as the countries become more similar. Indeed, this intuition is correct, as the following proposition shows.

**Proposition 8** A reduction in the factor price difference between the two countries, $d\theta > 0$, has the following effects:

$$df_1 < 0 \text{ and } dm_1 = \frac{E_2}{E_1}dm_2 < 0.$$  

**Proof.** See appendix. ■

Consider now a small increase in the number of entrants in country 1, $E_1$, holding the total number of entrants in the two countries, $E_1 + E_2$, fixed. That is, the aggregate mass of brands and entrepreneurs is held constant, while brands and entrepreneurs from country 2 are becoming relatively more scarce. This implies that a smaller fraction of entrepreneurs from country 1 will engage in cross-border acquisitions, while a larger fraction of entrepreneurs from country 2 will acquire brands in country 1. Holding $S$ fixed, this also implies that a larger fraction of entrepreneurs from country 1 will engage in greenfield FDI. Further, the shift in endowments in favor of the high-cost country results in a higher markup-adjusted residual demand level, which further increases the incentive to engage in greenfield FDI in the low-cost country. Clearly, a small increase in $E_2$, holding $E_1 + E_2$ fixed, has the opposite effects.

**Proposition 9** A small increase in the number of entrants in country 1, $E_1$, holding the total number of entrants, $E_1 + E_2$, fixed, has the following effects:

$$df_1 > 0 \text{ and } dm_1 = -dm_2 < 0.$$  

**Proof.** See appendix. ■

A small increase in the fraction of entrants who originate in country 1 makes the countries “more similar” if $E_1 < E_2$, and “more dissimilar” if the reverse inequality holds. An interesting question is whether the aggregate number of cross-border mergers, $E_1m_1 + E_2m_2$, increases or decreases as the two countries become more similar. From equations (18) and (19), we have

$$E_1m_1 + E_2m_2 = \frac{2E_1E_2}{E_1 + E_2} [H(\tilde{q}) - H(\theta \tilde{q})].$$

Recall that $\tilde{q}$ is independent of the number of entrants. Hence, the aggregate volume of cross-border mergers increases as the two countries become more similar.

**Corollary 1** Consider a small increase in the number of entrants in country 1, $E_1$, holding the total number of entrants, $E_1 + E_2$, fixed. Then, the aggregate number of cross-border mergers, $E_1m_1 + E_2m_2$, increases if $E_1 < E_2$, and decreases if $E_1 > E_2$. Hence, the aggregate number of cross-border mergers is maximized when $E_1 = E_2$.

Does the aggregate number of cross-border mergers increase or decrease as the two countries become more similar? As proposition 8 and corollary 1 show, the answer depends on which set of country characteristics one considers. As countries become more similar in terms of production costs, the aggregate two-way volume of cross-border mergers decreases, whereas the opposite result obtains as countries become more similar in terms of their populations of entrants. This shows that researchers need to be cautious when making claims about the relationship between country similarities and aggregate volume of cross-border mergers.
8 Conclusion

In this paper, we have presented a fresh perspective on the structure of foreign direct investment. We have uncovered two empirical regularities: (i) multinationals engaging in greenfield FDI are systematically more efficient than those engaging in cross-border acquisitions, and (ii) there is a strong positive relationship between the income level of the host country and the multinational’s propensity to favor cross-border acquisition over greenfield FDI. Both empirical regularities show that foreign direct investment can better be understood by distinguishing, both empirically as well as theoretically, between the two modes of FDI.

To this end, we have developed a novel theory of foreign direct investment that conceptually distinguishes between greenfield FDI and cross-border acquisitions. In our model, factor price differences between countries give rise to both greenfield FDI (from the high-cost to the low-cost country) and cross-border acquisitions (where each country acts as both a host and a home). In addition, cross-country differences in the shapes of the distributions of entrepreneurial abilities give rise to two-way cross-border acquisitions. Hence, for small factor price differences, most FDI takes the form of cross-border acquisitions. This can explain our empirical finding: a small fraction of FDI between rich and developed countries is in the form of greenfield FDI, while greenfield FDI plays a much more important role for FDI flows from rich and developed countries into poor and developing countries. While we have focused for convenience on cross-country differences in the distributions of entrepreneurial abilities, this result holds more generally as long as the shapes of the distributions of at least one firm-specific asset differ across countries.

Greenfield FDI involves the transfer of the production of brands from the high-cost country to the low-cost country. Since such transfer is costly, only the production of the best brands will be moved. On the other hand, the complementarities between brand qualities and entrepreneurial abilities induce positive assortative matching between the two types of firm-specific assets. Hence, greenfield FDI will involve the best brands and the best entrepreneurs. This explains our empirical finding: firms engaging in greenfield FDI are systematically more efficient than firms engaging in cross-border acquisitions. This may also explain why policymakers in many host countries favor greenfield FDI over cross-border acquisitions.

Greenfield FDI and cross-border acquisitions involve a change in the location of production of the best brands and a reassignment of entrepreneurs to brands in such a way that firm producing in the low-cost country are, on average, more efficient than firms producing in the high-cost country. While FDI may positively affect the distribution of firm efficiencies in one country, it may have the opposite effect in the other country. Indeed, if productivity is measured at the plant level, cross-border acquisitions tend to reduce the observed productivity of the plants in the high-cost country. A considerable fraction of observed productivity differences across countries may thus be due to endogenous sorting of firms (or firm-specific assets) into countries.

While outside the scope of this paper, our model may also fruitfully be used as a framework for policy analysis. For instance, it would be interesting to compute the welfare implications of various policy experiments, such as restrictions on cross-border acquisitions or greenfield FDI. From the host country’s point of view, cross-border acquisitions involve a change in ownership
of local production (and may even lead to the closure of local production), while greenfield FDI involves the opening of a new establishment. In this sense, cross-border acquisitions bring “less” to the host country’s economy than greenfield FDI. Moreover, greenfield FDI involves better foreign firms than cross-border acquisitions. Hence, the optimal government policy toward foreign direct investment should be tailored to the particular mode of FDI: greenfield FDI vs. cross-border acquisitions. We believe this to be an interesting avenue for future research.
Appendix: Tables

Table 1: Descriptive Statistics.

<table>
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<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
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<td>ACQ</td>
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<tr>
<td>OPEN</td>
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All data in logarithms.
Table 2: Greenfield FDI vs. Cross-Border Acquisitions. The Baseline Case.

<table>
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<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
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<td>LABORPROD</td>
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<tr>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.053)</td>
</tr>
<tr>
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</tr>
<tr>
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<td>(0.095)</td>
<td>(0.095)</td>
</tr>
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<td>(0.060)</td>
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Standard errors (shown in parenthesis) are adjusted for clustering by parent firm. All three specifications include fixed effects by parent industry.
Table 3: Greenfield FDI vs. Cross-Border Acquisitions. Full Set of Controls.

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<tr>
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<td></td>
<td></td>
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</tr>
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<td>(0.085)</td>
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<tr>
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<td>(0.315)</td>
</tr>
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Standard errors (shown in parenthesis) are adjusted for clustering by parent firm. All three specifications include fixed effects by parent industry.
Table 4: Greenfield FDI vs. Cross-Border Acquisitions. Fixed Effects by Affiliate Industry.

<table>
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<tr>
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<td>USSALES</td>
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<td>Efficiency</td>
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<tr>
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<td>(0.156)</td>
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<td>(0.159)</td>
</tr>
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</table>

Standard errors (shown in parenthesis) are adjusted for clustering by parent firm.
All three specifications include fixed effects by affiliate industry.
Appendix: Proofs

Proof of proposition 8. We first want to show that $\bar{q}$ is increasing in $\theta$. Let $\varphi(\theta, \bar{q})$ denote the r.h.s. of equation (14). Since $\partial \varphi(\theta, \bar{q}) / \partial \theta < 0$, we need to show that $\partial \varphi(\theta, \bar{q}) / \partial \theta > 0$. From (14), we obtain

$$
\frac{\partial \varphi(\theta, \bar{q})}{\partial \theta} = \sigma \phi \left[ E_1 \int_0^\theta q a_1(q) dH(q) + E_1 \theta \int_0^\theta q \frac{\partial a_1(q)}{\partial \theta} dH(q) 
+ E_2 \int_0^\theta q \frac{\partial a_2(q)}{\partial \theta} dH(q) \right] + a_2(\theta) \bar{q}.
$$

Changing variables, this expression can be rewritten as

$$
\frac{\partial \varphi(\theta, \bar{q})}{\partial \theta} = \sigma \phi E_1 \int_0^\theta q a_1(q) dH(q) + a_2(\theta) \bar{q}.
$$

Hence, $d\bar{q}/d\theta > 0$. From (22), it then follows immediately that $df_1/d\theta < 0$.

Consider now the share $m_1$ of entrepreneurs from country 1 who engage in cross-border mergers in country 2. From equation (21), we obtain

$$
\frac{dm_1}{d\theta} = \frac{E_2}{E_1 + E_2} \left\{-\tilde{q} h(\theta \bar{q}) + \left[h(\bar{q}) - \theta h(\theta \bar{q})\right] \frac{\bar{q}}{d\theta} \right\}.
$$

Since $\phi > \tilde{\phi}$ by assumption, $\tilde{q}$ is defined by $h(\tilde{q}) - \theta h(\theta \tilde{q}) = 0$. Hence, the above expression simplifies to

$$
\frac{dm_1}{d\theta} = -\frac{E_2}{E_1 + E_2} \tilde{q} h(\theta \tilde{q}) < 0.
$$

Similarly,

$$
\frac{dm_2}{d\theta} = -\frac{E_1}{E_1 + E_2} \tilde{q} h(\theta \tilde{q}) < 0.
$$

Proof of proposition 9. We first want to show that $\bar{q}$ is decreasing in $E_1$, holding $E_1 + E_2$ fixed. Let $\varphi(E_1, \bar{q})$ denote the r.h.s. of equation (14). Since $\partial \varphi(E_1, \bar{q}) / \partial \bar{q} < 0$, we need to show
that $\partial \varphi(E_1, \bar{\theta})|_{E_1+E_2=\text{const.}}/\partial E_1 > 0$. From (14), we obtain

$$ \frac{\partial \varphi(E_1, \bar{\theta})}{\partial E_1} |_{E_1+E_2=\text{const.}} = \sigma \phi \left[ \theta \int_0^{\bar{\theta}} q a_1(q) dH(q) - \int_0^{\bar{\theta}} q a_2(q) dH(q) + E_1 \theta \int_0^{\bar{\theta}} q \frac{\partial a_1(q)}{\partial E_1} dH(q) 
+ E_2 \int_0^{\bar{\theta}} q \frac{\partial a_2(q)}{\partial E_1} dH(q) \right] - \int_{\theta \bar{\theta}}^{\bar{\theta}} q \frac{\partial a_2(q)}{\partial E_1} dH(q) dq. \tag{23} $$

The sum of the third and fourth terms in brackets can be rewritten as

$$ E_1 \theta \int_0^{\bar{\theta}} q \frac{H(q) - H(\theta q)}{[E_1 + E_2] g(a_2(\theta q))} dH(q) + E_2 \int_{\theta \bar{\theta}}^{\bar{\theta}} q \frac{H(q/\theta) - H(q)}{[E_1 + E_2] g(a_2(q))} dH(q) + E_2 \int_{\theta \bar{\theta}}^{\bar{\theta}} q \frac{H(\bar{\theta}) - H(q)}{[E_1 + E_2] g(a_2(q))} dH(q). $$

Changing variables, we obtain

$$ \theta \int_0^{\bar{\theta}} q \left[ H(q) - H(\theta q) \right] \frac{E_1 h(q) + \theta E_2 h(\theta q)}{[E_1 + E_2] g(a_2(\theta q))} dq + E_2 \int_{\theta \bar{\theta}}^{\bar{\theta}} q \frac{H(q) - H(\theta q)}{[E_1 + E_2] g(a_2(q))} dH(q). $$

Integrating by parts yields

$$ -\theta \bar{\theta} [H(\bar{\theta}) - H(\theta \bar{\theta})] a_2(\theta \bar{\theta}) - \theta \int_0^{\bar{\theta}} a_2(\theta q) \{ [H(q) - H(\theta q)] + q [h(q) - \theta h(\theta q)] \} dq $$

$$ - \theta \bar{\theta} [H(\bar{\theta}) - H(\theta \bar{\theta})] a_2(\theta \bar{\theta}) - \int_{\theta \bar{\theta}}^{\bar{\theta}} a_2(q) \{ [H(\bar{\theta}) - H(q)] - q h(q) \} dq $$

$$ = -\theta \int_0^{\bar{\theta}} a_1(q) [H(q) - H(\theta q)] dq - \theta \int_0^{\bar{\theta}} q a_1(q) dH(q) + \int_{\theta \bar{\theta}}^{\bar{\theta}} q a_2(q) dH(q) $$

$$ - \int_{\theta \bar{\theta}}^{\bar{\theta}} a_2(q) [H(\bar{\theta}) - H(q)] dq + \int_{\theta \bar{\theta}}^{\bar{\theta}} q a_2(q) dH(q), $$

where the equality follows again from integrating by parts. Substituting this expression for the third and fourth terms in brackets in equation (23), we obtain that

$$ \frac{\partial \varphi(E_1, \bar{\theta})}{\partial E_1} |_{E_1+E_2=\text{const.}} = \sigma \phi \left[ -\theta \int_0^{\bar{\theta}} a_1(q) [H(q) - H(\theta q)] dq - \int_{\theta \bar{\theta}}^{\bar{\theta}} a_2(q) [H(\bar{\theta}) - H(q)] dq \right] - \int_{\theta \bar{\theta}}^{\bar{\theta}} q \frac{\partial a_2(q)}{\partial E_1} \left|_{E_1+E_2=\text{const.}} dq \right. $$

$$ = -\sigma \phi \theta \int_0^{\bar{\theta}} a_1(q) [H(q) - H(\theta q)] dq - \int_{\theta \bar{\theta}}^{\bar{\theta}} a_2(q) [H(\bar{\theta}) - H(q)] dq $$

$$ - \int_{\theta \bar{\theta}}^{\bar{\theta}} q \frac{H(\bar{\theta}) - H(q)}{[E_1 + E_2] g(a_2(q))} dq, $$
which is clearly negative. From (22), it then follows that $f_1$ is increasing in $E_1$, holding $E_1 + E_2$ fixed.

Observing that $\hat{q}$ is independent of $E_1$ (since $\phi > \hat{\phi}$ by assumption, we obtain from (21) that

$$\frac{dm_1}{\partial E_1}|_{E_1+E_2=\text{const.}} = -\frac{H(\hat{q}) - H(\theta \hat{q})}{E_1 + E_2} < 0,$$

and

$$\frac{dm_2}{\partial E_1}|_{E_1+E_2=\text{const.}} = \frac{H(\hat{q}) - H(\theta \hat{q})}{E_1 + E_2} > 0.$$

