Cross-Border Mergers and Acquisitions with Heterogeneous Firms: Technology vs. Market Motives

by

Donghyun Lee*

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Abstract

The most common form of foreign direct investment (FDI) is cross-border mergers and acquisitions (M&A). A common explanation for M&A activity identified in the industrial organization literature is that firms seek technological expertise. However, this has not been examined in the FDI literature. In this paper, I develop and estimate a model of cross-border M&A and focus on the technology seeking explanation. In particular, I develop a general equilibrium model of exporting, greenfield FDI, technology-seeking cross-border M&A, and market-seeking cross-border M&A with heterogeneous firms. The model predicts that firms from a larger country are more likely to acquire in a smaller country when M&A activity is driven by a technology-seeking motive, but the opposite is true when it is driven by a market-seeking motive. Using detailed data on worldwide M&A activity from 1985-2007, I find empirical evidence that cross-border M&A activity exhibits behavior consistent with this prediction.

JEL Codes: F1, F12, F21, F23

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* Department of Economics, University of Oregon, Eugene, OR 97403; E-mail: dlee12@uoregon.edu. Phone: 541-579-3109. The author thanks Bruce Blonigen, Neviana Petkova, Nicolas Sly, and Wesley Wilson for valuable comments and discussion. I would also like to thank Jeffrey Nugent, participants at WEAI's Graduate Student Dissertation Workshop, and session participants at WEAI's annual conference in Portland. All remaining errors or omissions are the responsibility of the author.

1. INTRODUCTION

Foreign direct investment (FDI) has played a major role in the increasing economic globalization of the past couple decades. Cross-border M&A is the major source of FDI, particularly for developed countries accounting for as much as two-thirds of FDI (World Investment Report 2007). Thus, understanding cross-border M&A plays a crucial role in understanding FDI and globalization.

Various motives can exist for firms to engage in cross-border M&A. Firms may engage in cross-border M&A to obtain market-specific expertise[1] of the host country in order to better serve the host country's consumers. Nocke and Yeaple (2007) build a theoretical model based on this motivation.[2] Firms may also engage in cross-border M&A for corporate control. This motive is the driving force behind the M&A model in Head and Ries (2008).

In this paper, I contribute to the growing cross-border M&A literature by building a model where M&A activity is potentially motivated by technology. A technology-seeking motive is important in M&A activity, as evidence for this motive can be found from various empirical articles (mostly on domestic M&A) in other literatures. For example, studies on pharmaceutical firms in the industrial organization literature show that firms engage in M&A when seeking patents for drugs, which is an important technology in pharmaceutical industry (see, for example Gans *et al* (2002) and Danzon *et al* (2004)).

[1] This can be knowledge on local marketing strategies or distribution channel that is country-specific. This motivation is present in my model as well.

[2] Their basic theoretical framework is similar to Helpman, Melitz and Yeaple (2004) with heterogeneous firms, which is also the case for my model. This is a standard setup for foreign market entry models with heterogeneous firms.

Other studies also show that there exists a high correlation between R&D expenditure in a firm or in an industry and M&A activities, and firms will use M&A to substitute "bought" technology for internally-produced technology (see, for example Blonigen and Taylor (2000), Blonigen (1997), and Kogut and Chang (1991)).

I extend a model introduced by Nocke and Yeaple (2007) to include a technology-seeking motive for cross-border M&A and develop a general equilibrium model of exporting, greenfield FDI, technology-seeking cross-border M&A, and market-seeking cross-border M&A with heterogeneous firms. The model is developed from the firm entry model where there exists a competitive market for M&A, and firms engage in cross-border M&A for two reasons: (1) To gain a synergy effect[3] by obtaining a target firm's technology, which increases the acquirer's productivity, or, (2) to obtain a target firm's market-specific expertise, such as knowledge on local marketing strategies or distribution channel, which makes the acquirer's goods more desirable to consumers in the host country.[4] I term the first motive "technology-seeking" and the second motive "market-seeking" throughout the rest of the paper.

I first show that there are distinct productivity cutoffs in the model that separate exporting, greenfield FDI, technology-seeking cross-border M&A, and market-seeking cross-border M&A in equilibrium and show how different firm types sort into these foreign market access modes.

[3] Synergy is realized because the target firm from another country has a technology that is different from the acquirer. Empirical evidence of this effect can be found in the following articles (see, for example Morosini et al (1998), Vermeulen & Barkema (2001), and Gertsen et al (1998)) and (Branstetter (2000), Takechi (2006), and Guadalupe et al (2010)).

[4] This is similar to the cross-border M&A motive used by Nocke and Yeaple (2007).

Second, I show that the model generates a sharp theoretical distinction between the two motives: Relative country size differences between the home and the host countries will have a different effect on technology-seeking cross-border M&A and market-seeking cross-border M&A. In particular, proportionately more firms engage in technology-seeking cross-border M&A, the bigger their home country's size is relative to the host country, whereas the opposite is true for market-seeking cross-border M&A. This provides me with an estimation strategy to identify the technology-seeking motive in the data. I provide evidence of this result by showing that cross-border M&A into high-R&D sectors[5] in the host country increases approximately by a factor of 1.13 as the relative size difference between the home and the host country (i.e. home country size minus host country size) increases, suggesting that the bigger the home country is relative to the host country, more firms from the home country engage in technology-seeking cross-border M&A into the smaller host country.

The rest of the paper proceeds as follows. Section 2 describes the theoretical model. Section 3 analyzes the equilibrium of the model and determines the equilibrium pattern of the four foreign market entry modes (i.e. exporting, greenfield FDI, technology-seeking cross-border M&A, and market-seeking cross-border M&A). Section 4 looks at how asymmetric country size affects the equilibrium using comparative statics to uncover the technology-seeking motive. Section 5 conducts an empirical analysis suggested by the comparative statics result and provides evidence of a technology-seeking motive consistent

[5] M&As that take place in these sectors are likely to be technology-seeking since firms in these sectors are technology-intensive.

with the model's prediction using worldwide cross-border M&A data. The last section presents conclusions.

2. THE MODEL

The model consists of two identical countries 1 and 2. The aggregate income level in both countries is denoted by *Y*. Labor is the only factor of production. The price of labor in each country is equal and normalized to one because a homogeneous and perfectly competitive product is produced in every country and traded freely.[6][7] The homogeneous product is produced with one unit of labor per unit of output. The model is developed from a firm entry model where there exists a competitive market for M&A. I seek the subgame perfect equilibrium of the game. The timing of the each stage is as follows:

Stage 1: Potential entrants decide whether to enter the market or not in each country.

Stage 2: Firms decide on how to serve the foreign market to maximize their profits by choosing from the following entry modes; 1) exporting, 2) greenfield FDI, 3) participate in the cross-border mergers and acquisitions market as buyers or sellers (either technology-seeking or market-seeking).

Stage 3: Firms compete in the market as price setters and receive profits. Firms can discriminate between markets and set different prices for the two countries.

[6] In fact, I already assume countries are identical thus wages are equal and homogeneous good may seem unnecessary. However, homogeneous good insures the wages are equal later when I do comparative statics where country sizes aren't identical.

[7] This model best represents horizontal FDI between developed countries but not vertical FDI since there are no wage differences between the two countries which firms can exploit.

2.1. Preferences

The representative consumer has CES preferences over varieties of each differentiated good and Cobb-Douglas preferences over the differentiated goods and the homogeneous good. The representative consumer spends αY on the differentiated goods and $(1-\alpha)Y$ on the homogeneous good. Consumer's utility over the varieties of the differentiated goods and the homogeneous good can be written as:

$$U = [\int_{\omega\in\Omega} q(\omega)^{1-\rho} x(\omega)^{\rho} d\omega]^{\frac{\alpha}{\rho}} Z^{1-\alpha}\ ,\ \rho = \frac{\sigma-1}{\sigma},\ \sigma > 1 \tag{1}$$

where $x(\omega)$ and $q(\omega)$ are the level of consumption and the perceived quality of variety ω, respectively. The variable Z is the level of consumption of the homogeneous good, and σ is the elasticity of substitution across varieties.

2.2. Entry

There is a continuum of atomless and *ex ante* identical potential entrants. They can only enter in their own country and are each endowed with the knowledge to produce a unique good. If an entrant decides not to enter, it obtains a payoff of zero. If it decides to enter the entrant must pay an entry fee of F_e. After the entrant enters, it receives a random draw of a technological capability $\tilde{m}$ from distribution H with support $(0,\infty)$, and a market-specific expertise.[8] The market-specific expertise is not drawn from a distribution and the same market-specific expertise is given to all the entrants entering in the same

[8] Nocke and Yeaple (2007) used the terminology mobile capability for technological capability and non-mobile capability for market-specific expertise.

country. This is different from Nocke and Yeaple (2007), where market-specific expertise is drawn from a step function. Assuming that it is not drawn from a step function allows me to skip the domestic acquisition process. Results will still hold even if I assume that market-specific expertise is drawn from a step function. Also, since I am mainly interested in technology as an incentive for cross-border acquisition I only focus on the case where technological capability is drawn from a continuous distribution, unlike Nocke and Yeaple (2007).

2.3. Firms

Firms differ in their capabilities. There are two different capabilities that firms receive upon entry. The first is a technological capability. The efficiency of a firm's production technology is assumed to depend on this capability $\tilde{m}$. A firm's marginal cost $c(\tilde{m})$ is the inverse of $\tilde{m}$:

$$c(\tilde{m}) = \frac{1}{\tilde{m}} \tag{2}$$

The second capability is the market-specific expertise, such as knowledge of local marketing strategies or distribution channels that is country-specific. Firms receive market-specific expertise of their home country upon entry. This is country-specific and is not given to foreign firms. A market-specific expertise is more effective in its country of origin than abroad; that is, domestic firms have better marketing strategies for the domestic consumers than foreign firms. There is empirical evidence supporting this idea (see, Maurin *et al.*). This is reflected in $q(\omega)$, the perceived quality of the product. If the firm uses its market-specific expertise originating in country i for serving country i then its perceived quality in that country is $q^i = 1$. But if it uses this capability to serve country j then its perceived quality in country j is only $q^j = \delta$, where $\delta \in (0,1)$.

2.3.1. *Additional frictional costs*

There are other frictional costs incurred by a foreign firm when selling its products across borders. These are the same frictional costs also imposed by Nocke and Yeaple (2007) in their model. First, there is a fixed coordination cost F_c associated with managing production in country i while using a market-specific expertise originating from country j to serve country i. This coordination cost can be avoided if production takes place only in country i and the firm uses a country i's market-specific expertise or if production takes place in both countries and the firm uses a market-specific expertise from each country. Second, iceberg-type transportation costs are incurred for shipping output across borders: $\tau > 1$ units need to be shipped for one unit to arrive in the foreign country. Thus, if the good is produced in country i and then shipped to country j, the marginal cost of serving country j is $\tau c(\tilde{m})$. For notational convenience, I define the following transformations of $\tilde{m}$ and τ : $m \equiv \tilde{m}^{\sigma-1}$ and $T \equiv \tau^{-(\sigma-1)}$, with T<1.

2.4. Foreign market access

All firms serve their home market entirely from local production, but the way they serve the foreign market can differ depending on their productivities. Firms have the choice of serving the foreign market by exporting, greenfield FDI, or by participating in the international M&A market. A firm may choose greenfield FDI to avoid the iceberg-type transportation cost, but it must incur a fixed cost F_c. A firm can avoid this fixed cost by exporting, but in this case it must incur the iceberg-type transportation cost. Alternatively, a firm can engage in cross-border M&A to serve the foreign market by purchasing a target firm. There are two possible motives for cross-border M&A; (1) To gain a synergy effect by obtaining a target firm's technological capability, or, (2) to obtain a target firm's market-specific expertise.

2.4.1. *Technology-seeking M&A*

If a firm acquires a target firm from another country, the target firm's technological capability is transferred directly to the acquiring firm upon acquisition and synergy is realized. The synergy is realized because the target firm from another country has a technology that is different from the acquirer that gives a different perspective.[9] Specifically, the merged firm's marginal cost becomes:

$$c(\tilde{m}) = \frac{1}{\tilde{m} \times \tilde{g}} \tag{3}$$

where, $\tilde{g} > 1$ reflects the synergy gain from the merger. Note that the realized synergy parameter, $\tilde{g}$, is constant and doesn't depend on the target's technological capability. This simplifies the calculations, though Appendix A shows that I get the same results if I assume

[9] The target's technological capability does not have to be necessarily more efficient than the acquirer, for the synergy to be realized. If the target's technological capability gives a different perspective on producing the product unknown to the acquirer, this could be enough for the synergy effect to be realized. There are also articles that support this idea (see Appendix A). More detailed discussion on this is in the Appendix A.

that $\tilde{g}$ increases as target's $\tilde{m}$ increases. For notational convenience, I define the following transformation of $\tilde{g}$: $g = \tilde{g}^{\sigma-1}$. Note g >1. Synergy effect is not present in Nocke and Yeaple's (2007) model. This is something I newly introduce to the literature to analyze technology-seeking cross-border M&A.

2.4.2. *Market-seeking M&A*

Market-seeking M&A is motivated by a firm's desire to increase the perceived quality of its good in the foreign country by obtaining the foreign country's market-specific expertise and to avoid the fixed coordination cost F_c. However, the acquirer can access the market-specific expertise of the target firm only after paying a fixed integration cost (*IC*) in addition to the target firm's purchase price (I assume $IC > F_c$). Such costs may arise, for example, if the acquirer and the target come from very different cultural backgrounds and the acquirer then has difficulties in integrating the target's market-specific expertise. The integration cost of cross-border M&A due to cultural differences is the subject of an extensive literature (See, for example, Finkelstein (1999), Zhu and Huang (2007), Drogendijk and Slangen (2006)).[10]

2.4.3. *Equilibrium price in M&A market*

There exists a perfectly competitive M&A market where entrants can be bought and sold. In this model, target firms' prices are equal because no matter what target firms'

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[10] More detailed discussion on this and a descriptive statistical evidence of *IC* is in the Appendix A. *IC* is not present in Nocke and Yeaple's (2007) model.

types are, they all give the same synergy effect and the same market-specific expertise to the foreign acquirer; i.e. target firms' values are identical to potential acquirers.[11] Thus, there only exists one equilibrium price, which I'll denote as Q. This price is determined by the supply of the target firms and the demand of the target firms by foreign acquirers.

2.4.4. *Summary of foreign market access modes and associated costs*

Depending on the firm's choice of foreign market entry mode, associated costs can be summarized as follows:

1. Exporting: No fixed cost, but incurs iceberg type transportation cost.
2. Greenfield FDI: Incurs a fixed coordination cost F_c, but no transportation cost.
3. Technology-seeking cross-border M&A: Incurs a fixed purchase cost Q and a fixed coordination cost F_c, but no transportation cost.
4. Market-seeking cross-border M&A: Incurs a fixed purchase cost Q and a fixed integration cost IC, but no fixed coordination cost F_c and no transportation cost.

3. THE INTERNATIONAL ORGANIZATION OF PRODUCTION

In this section, I analyze the equilibrium of the model and determine how firms select into different foreign market entry modes (i.e. exporting, greenfield FDI, technology-seeking cross-border M&A, and market-seeking cross-border M&A) in equilibrium. I start by deriving the gross profits of firms at the third stage.

[11] This is similar to Nocke and Yeaple (2007).

Solving the representative consumer's utility maximization problem, I obtain the following demand function for any variety ω in country *k*:

$$x^k(\omega) = \alpha Y (P^k)^{\sigma-1} q^k(\omega) p^k(\omega)^{-\sigma} \tag{4}$$

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

$$P^k = [\int_{\omega\in\Omega} q^k(\omega) p^k(\omega)^{1-\sigma} d\omega]^{1/1-\sigma} \tag{5}$$

the aggregate price index for the varieties produced in country *k*. Since countries are symmetric, the price indices in the two countries are the same: i.e. $P^1 = P^2 = P$.

Let $\hat{c}^k(\omega)$ denote the marginal cost of selling variety ω in country *k*, including the iceberg-type transportation cost. Since this is monopolistic competition and firms can price discriminate between countries, profit maximization then implies that the price of variety ω $p^k(\omega)$ is equal to $\hat{c}^k(\omega)/\rho$. Hence, the gross profit of a firm selling variety ω in country *k* is given by,

$$Sq^k(\omega)(\hat{c}^k(\omega))^{1-\sigma} \tag{6}$$

where,

$$S = \frac{\alpha Y}{\sigma(\rho P)^{1-\sigma}} \tag{7}$$

Now, by using (6) and by associating the fixed costs incurred for each foreign entry mode, I derive the following total profits generated from domestic and foreign countries depending on the firm's entry mode:

	Total Profit
Exporting	$\pi_x(m) = (1+T\delta)Sm$
Greenfield FDI	$\pi_f(m) = (1+\delta)Sm - F_c$
Technology-seeking cross-border M&A	$\pi_g(m) = (1+\delta)Smg - Q - F_c$
Market-seeking cross-border M&A	$\pi_a(m) = 2Smg - Q - IC$

In the second stage, firms decide on the entry mode that maximizes their total profits. This depends on their technological capability *m*, because total profit is increasing in *m,* but at different rates (i.e. different slopes) for each entry mode. In fact, if I take the partial derivative of the profits with respect to *m*, I can order the slopes as; $0 < \pi_x'(m) < \pi_f'(m) < \pi_g'(m) < \pi_a'(m)$, and therefore, I obtain the following result.

Proposition 1. *In equilibrium there exist four thresholds,* $0 < m_s < m_x < m_g < m_a$ *such that, firms with a technological capability between* $(0, m_s)$ *sell themselves in the cross-border M&A market, firms with a technological capability between* $[m_s, m_x)$ *export, firms with a technological capability between* $[m_x, m_g)$ *engage in greenfield FDI, firms with a technological capability between* $[m_g, m_a)$ *engage in technology-seeking cross-border M&A, firms with technological capability between* $[m_a, \infty)$ *engage in market- seeking cross border M&A.*

Graphical illustration of Proposition 1 is shown in figure 1. Each curve represents the profit functions ($\pi_x(m), \pi_f(m), \pi_g(m), \pi_a(m)$) and the horizontal line is the target firm's price *Q*. The bolded section of the curve indicates that the corresponding entry mode (or becoming a target at price *Q*) gives the firm the highest total profit given the firm's current technological capability *m*. Therefore, firms are partitioned into five different subsets according to their technological capability: 1) become a target and earn *Q* (if it can't generate a profit higher than *Q* from other entry modes), 2) become an exporter and earn $\pi_x(m)$, 3) engage in greenfield FDI and earn $\pi_f(m)$, 4) engage in technology-seeking cross-border M&A and earn $\pi_g(m)$, 5) engage in market-seeking cross-border M&A and earn $\pi_a(m)$. Firms sort into these five cases depending on their technological capability.

Also, the four thresholds are shown in the figure, each of which occurs at the intersections of the curves.

The values of the four thresholds are as follows:

Equate $\pi_x(m)$ and Q, $$m_s = \frac{Q}{(1+T\delta)S} \tag{8}$$

Equate $\pi_x(m)$ and $\pi_f(m)$, $$m_x = \frac{F_c}{S\delta(1-T)} \tag{9}$$

Equate $\pi_f(m)$ and $\pi_g(m)$, $$m_g = \frac{Q}{(1+\delta)(g-1)S} \tag{10}$$

Equating $\pi_g(m)$ and $\pi_a(m)$, $$m_a = \frac{IC - F_c}{S(1-\delta)g} \tag{11}$$

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

$$\int_0^\infty V(m)dH(m) - F_e = 0 \tag{12}$$

where *V(m)* is the value of a firm after entering the market, which depends on the profit it generates.

Lastly for the merger market to clear, the mass of target firms must be equal to the mass of acquirers. Let E be the mass of entrants in both countries (E is same in both countries because they are identical). Then the mass of targets, $EH(m_s)$ must equal the mass of acquirers, $E(1-H(m_g))$. This simplifies to:

$$H(m_s) + H(m_g) = 1 \tag{13}$$

4. ASYMMETRIC COUNTRY SIZE AND M&A ACTIVITY

In this section, I analyze how asymmetric country size between the two countries in my model can affect the equilibrium thresholds, especially m_g and m_a. I undertake this comparative static exercise to provide me with a sharp prediction about how M&A activity varies with the separate cross-border M&A motives; i.e. technology-seeking versus market-seeking motives. The effect of asymmetric country size on the market-seeking motive is similar to Nocke and Yeaple (2004) in my model. However, asymmetric country size has an opposite effect on M&A activity motivated by technology-seeking.

The motivation behind acquiring market-specific expertise from a country is to raise demand for a firm's good in that country. On the other hand, the motivation behind acquiring technological capability is to get a synergy effect, which is independent of access to the foreign market. Thus, if we have two countries with different sizes, intuitively firms from the smaller country will be relatively more interested in the market-specific expertise of the larger country and less interested in the technological capability because the profit increase from accessing the larger country's market is relatively large. On the other hand, firms from the larger country will be relatively more interested in the technological capability of the smaller country and less interested in the market-specific expertise because the relative profit increase from accessing the smaller country's market is small. Using comparative statics I show separation of the two cross-border M&A motives consistent with this intuition.

To address how country size differences affect the equilibrium outcome, I consider a change in country sizes that maintains global income so that $dY^k = -dY^l > 0$. Then I use the following lemma from Nocke and Yeaple (2004) to analyze how this change in income affects the endogenous variables in my model.

Lemma 1 *Suppose the two countries are initially of the same size, i.e.* $Y^1 = Y^2$ *, and consider a small change in country sizes such that* $dY^k = -dY^l$*. Then, the change in any endogenous variable u has the same absolute value in the two countries, but is of opposite sign:* $du^k = -du^l$.
Proof of Lemma 1 is in the Appendix B.

By applying Lemma 1, I can derive the following proposition.

Proposition 2. *Suppose the two countries are initially of the same size, i.e.* $Y^1 = Y^2$*, and consider a small increase in the size of country k and a small decrease in the size of country* $l \neq k$ *such that* $dY^k = -dY^l > 0$.
Then, $dm_s^k = -dm_s^l < 0$, $dm_x^k = -dm_x^l > 0$, $dm_g^k = -dm_g^l < 0$, and $dm_a^k = -dm_a^l > 0$.

Proof of Proposition 2 is in the Appendix B.[12]

Figure 2 illustrates the movements of the thresholds from their initial points as country size changes (the arrows indicate the direction of the movements from their initial points). Since, $dm_g^k = -dm_g^l < 0$ and $dm_a^k = -dm_a^l > 0$, the threshold m_g falls and the threshold m_a rises in country *k* (the larger country), implying that proportionately more firms in country *k* are now engaging in cross-border M&A to obtain the synergy effect and proportionately less firms are engaging in market-seeking cross-border M&A. The opposite is true in country *l* (the smaller country) since the threshold m_g went up and the threshold m_a went down.

[12] Note, this proposition is true conditional on the fact that the acquisition price *Q* that firms has to pay does not change as much when countries' sizes change. I will illustrate this in detail in my proof in the appendix.

5. EMPIRICAL EVIDENCE

5.1. Specification

In this section, I conduct an empirical analysis to examine the hypothesis that asymmetric country size will have different impacts on M&A activity, depending on whether it is motivated by technology-seeking or market-seeking behavior.

Nocke and Yeaple (2004) shows that when only the market-seeking motive exists for cross-border M&A, proportionately more firms in the home country engage in cross-border M&A into the host country as the home country's size decreases relative to the host country. This indicates that the level of cross-border M&A deals is an inverse function of the size difference (i.e. home country size minus host country size):

$$MA_{ijt} = f(size_{jt} - size_{it}) \tag{14}$$

where j denotes the home country and i denotes the host country. The MA_{ijt} variable is the cross-border M&A activity in country i from country j in time t, $size_{jt}$ is the size of country j at time t, and $size_{it}$ is the size of country i at time t. Then, $(size_{jt} - size_{it})$ should have a negative effect on MA_{ijt}, if acquisition of market-specific expertise is the only cross-border M&A motive.

In contrast, Proposition 2 in the previous section predicts that $(size_{jt} - size_{it})$ has a positive effect on MA_{ijt} when a technology-seeking motive is driving cross-border M&A activity. As the home country's size increases relative to its host country, proportionately more firms from the home country engage in technology-seeking cross-border M&A into the host country.

To distinguish between these two contrasting predictions, I need to identify situations in which a technology-seeking motive is important vis-à-vis a market-seeking motive. To do this, I modify equation (14) to include an interaction term between the size difference variable and an indicator variable that takes a value of one when M&A deal is technology-seeking and zero when it isn't:

$$MA_{ijt} = f(tech(size_{jt} - size_{it}), (size_{jt} - size_{it})) \tag{15}$$

where the interaction term should have a positive effect on MA_{ijt} if Proposition 2 is correct. The relationship between the interaction term and MA_{ijt} from equation (15) provides an estimation strategy that I can take to the data to identify the evidence for Proposition 2's prediction when technology-seeking motive is present.

The following is the related estimating specification for equation (15):

$$MA_{ijkt} = \beta_{ikt} + \delta_1 tech(size_{jt} - size_{it}) + \delta_2 (size_{jt} - size_{it}) + \delta_3 tech + \varepsilon_{ijkt} \tag{16}$$

The dependent variable, MA_{ijkt} is the number of firms acquired in country i in industry k by firms in country j in time t. My dependent variable is constructed at the four-digit SIC industry level from the mergers and acquisitions data at SDC Platinum. If an acquirer acquires 10% or more of the target's shares, I consider this as an acquisition.[13] The value of M&A deals cannot be used since they are not consistently available in the

[13] This is because 10% or more is considered as an acquisition in United States. The regression results are still the same when 50% or 100% is used instead as the threshold level.

data. Since the dependent variable is count data, negative binomial estimation will be used.[14]

The size difference variable, $(size_{jt} - size_{it})$ is equal to the log of real GDP_{jt} minus the log of real GDP_{it}, which captures the country size difference between the home and the host countries. Real GDP is used to measure country size because country size is represented by aggregate income in my model.

There is no way of knowing the true motivation behind the cross-border M&A that took place because firms don't report the exact reason for acquisition. However, R&D expenditures are a commonly used proxy for indicating the importance of technology in an industry and I use it here for this purpose as well.[15] Thus, I specify the indicator variable for technology-seeking motive, $tech$, as taking the value of "1" for industries with high R&D expenditures. Later, I explore other proxies for the $tech$ variable.

I separate the high R&D industries and low R&D industries by using the R&D expenditures as a percentage of sales data obtained from National Science Foundation to construct $tech$, and categorize industries as high R&D industries if those industries have R&D expenditures as a percentage of sales that are at or above the mean of the manufacturing sector.[16]

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[14] I use negative binomial model instead of poisson model because summary statistics suggests that dependent variable is over-dispersed (i.e. mean <variance).

[15] I also try using high-tech share to proxy for the importance of technology in an industry. I still get similar results. Discussion and results on this are in the robustness checks section.

[16] This method has been used by Blonigen (1997) to separate high-tech industries from low-tech industries in manufacturing sector.

The main variable of interest is the interaction term. Proposition 2 implies that technology-seeking cross-border M&A into host country will increase as relative size difference between the home and the host country increase. Thus, the main coefficient of interest is the coefficient on the interaction term and I expect the coefficient on it to be positive and significant. I include the size difference and *tech* variable separately in all my estimations to control for any independent effects of these variables on cross-border M&A activity.

Industry and time fixed effects, β_{ikt} are included to capture any industry-specific favorable environment for acquisition at time t in the host country i.[17] The ε_{ijkt} denotes the error term.

5.1.2. *Additional control variables*

After providing initial baseline estimates of equation (16), I explore how robust my results are to including other control variables that can potentially affect cross-border M&A. Most of these control variables are taken from previous trade literature papers such as Di Giovanni (2005) and Head and Ries (2008), which estimate the determinants of cross-border M&A activity.

First, annual real GDP growth rate of the home country, $realgdpg_{jt}$, is included to control for demand side factors. I expect this variable to have a positive effect on the dependent variable.

[17] Note that *tech* variable drops because of perfect multicollinearity with the fixed effects.

Second, I include $\ln(exch_{ijt})$, a logged exchange rate between countries *i* and *j* at time *t*. This is a relevant control variable because Blonigen (1997) suggests that depreciation of the domestic currency can encourage inflow of asset seeking type acquisition FDI. The exchange rates are denominated in home country's currency per host country's currency. Thus, a decrease in this variable implies depreciation of the host country's currency. I log the exchange rates so that percentage changes in exchange rates for different country pairs are comparable. I expect this to have a negative effect on the dependent variable.

Third, I include stock market capitalization as a percentage of GDP of the home country, $stockcap_{jt}$, as a control variable because financial deepening (i.e. increase in the size of financial markets) of the home country can influence cross-border M&A, as suggested by Di Giovanni (2005). I expect this to have a positive effect on the dependent variable.

Fourth, I also include domestic credit provided to the private sector as a percentage of GDP of the home country, $credit_{jt}$, as a control variable. This is another variable suggested by Di Giovanni (2005) to account for the effect of financial deepening on cross-border M&A. I expect this to have a positive effect.

Fifth, I include the distance between the home and the host countries' capital cities (in miles), $distance_{ij}$, as a control variable. The gravity model suggests that there's less foreign direct investment when the distance between the home and the host countries increases. I expect this to be true for cross-border M&A activity as well. Thus, I expect this variable to have a negative effect on the dependent variable.

Sixth, I include the following dummy variables: common language usage dummy variable, $lang_{ij}$, directional dummy variables $ToColy_{ij}$, which indicates M&A to a former colony from its colonizer, and $FromColy_{ij}$, which indicates M&A from a colony to its colonizer. These variables are included to control for the cultural distance between the home and the host countries that can potentially affect the dependent variable. Empirical evidence from the trade literature suggests that cultural similarity between the home and the host countries increase foreign direct investment activities between the two countries. Thus, I expect these variables to have a positive effect on the dependent variables. The three dummy variables $lang_{ij}$, $ToColy_{ij}$, and $FromColy_{ij}$ have also been used in Head and Ries' (2008) paper to measure cultural distance.

Finally, I include a time-varying dummy variable, rta_{ijt}, that takes a value of one when the home and the host countries belong to a common regional trade agreement. Trade agreement variable has frequently been used in past FDI or cross-border M&A studies as a control variable (e.g. Di Giovanni (2005)).

The following is the estimating specification with additional controls included:

$$MA_{ijkt} = \beta_{ikt} + \delta_1 tech(size_{jt} - size_{it}) + \delta_2 (size_{jt} - size_{it}) + \delta_3 tech + \delta_4 realgdpg_{jt}$$

$$+\delta_5 \ln(exch_{ijt}) + \delta_6 stockcap_{jt} + \delta_7 credit_{jt} + \delta_8 distance_{ij}$$

$$+\delta_9 lang_{ij} + \delta_{10} ToColy_{ij} + \delta_{11} FromColy_{ij} + \delta_{12} rta_{ijt} + \varepsilon_{ijkt} \qquad (17)$$

5.2. Data

I use the mergers and acquisitions data from Thomson SDC Platinum (software which contains data on M&A, loans, equity etc), which has data on acquired firms by foreign and domestic firms in various countries to construct my dependent variable.[18] If the percentage of shares acquired by a foreign firm is 10% or more, I consider this as an acquisition. SDC Platinum also has SIC codes at the four-digit level for each acquired firm and provides the country of origin of the firms that are engaged in acquisition.

Using the data set, I create a M&A count dependent variable at the four-digit SIC industry level and form a panel data set that ranges from 1985 to 2007, for the OECD countries (except Slovakia).[19] I use OECD countries because more than 70% of FDI activities are among the developed countries. All countries in my sample are both host and home countries.

R&D expenditures as a percentage of sales data used for creating the high R&D industry dummy variable (*tech*) are obtained from the U.S. National Science Foundation. Annual real GDP growth rates are obtained from the United States Department of Agriculture (USDA) website.[20] Exchange rate data are obtained from the Pacific Exchange Rate Service.[21] The stock market capitalization to GDP and domestic credit to GDP data are obtained from the World Development Indicators database from the World Bank. The distance variable is constructed using the great circle distance calculator[22].

[18] Further information on these data are at: http://www.thomsonreuters.com/products_services/financial/sdc
[19] M&A data for Slovakia is not included in SDC Platinum.
[20] Link to this data source: http://www.usda.gov/
[21] Link to this data source: http://fx.sauder.ubc.ca/
[22] Link to this calculator: http://www.marinewaypoints.com/learn/greatcircle.shtml

The three dummy variables $lang_{ij}$, $ToColy_{ij}$, $FromColy_{ij}$ and the time-varying dummy variable, rta_{ijt} are obtained from the *cepii.fr* website.

Figure 3 shows the cross-border M&A deals into OECD countries in my dataset from 1985 to 2007. Cross-border M&A deals have been growing steadily since 1985. Although M&A deals dropped in 2001 and 2002, they began to increase again in 2003 and this trend continued through the end of the sample in 2007. This trend is consistent with other sources, which highlight the growing trend of cross-border M&A over the past couple of decades. Table 1 shows the summary statistics of the variables.

5.3. Results

Regression results for equation (16) are provided in the first column of Table 2. The coefficient on the interaction term is positive and significant which is consistent with my prediction and suggests that cross-border M&A into host country's high R&D industries increases as relative size difference between the home and the host country increases. Assuming the *tech* dummy variable correctly proxies for the technology-seeking motive, this implies that the bigger the home country is relative to the host country, more firms in the home country engage in technology-seeking cross-border M&A into the smaller host country. Thus, this supports Proposition 2's prediction of technology-seeking motivated cross-border M&A behavior when country sizes are asymmetric.

Coefficient estimates in a negative binomial model are not straightforward to interpret. Incidence rate ratio interpretation is more commonly used for negative binomial models. The second column of Table 2 presents the incidence rate ratio for each coefficient. By using this ratio, the effect of the interaction term on the dependent variable can be interpreted as follows: one unit increase in the size difference variable increases the cross-border M&A in high R&D industries by a factor of 1.132.

An interesting observation is that the coefficient on the size difference variable is positive and significant; i.e. size difference has a positive effect on cross-border M&A activities overall. This is counter to what Nocke and Yeaple (2004) predicts where market-seeking is the sole motive for cross-border M&A, because in that case, size difference variable should have a negative effect on cross-border M&A. In fact, based on my prediction from Proposition 2, this indicates that the technology-seeking motive rather than market-seeking motive is much more prevalent in other industries as well. Also, considering that countries in my sample are all industrialized countries, this result can shed some light on the motive behind horizontal FDI. My result is counter to the common belief in FDI literature that firm's motive behind horizontal FDI is to access the foreign market. As a matter of fact, it suggests that technology-seeking motive is much more common than market-seeking motive.

Table 2, column 3, shows the regression results for equation (17), which includes additional control variables. My results are robust to additional control variables. The magnitude of the main coefficient (i.e. the interaction term) has not changed much compared to the baseline estimation, and it is still statistically significant and has a positive sign. The coefficient for the size difference variable is significant and similar in magnitude and has the same sign as the coefficient from the baseline estimation.

The coefficient on the annual real GDP growth rate of the home country has the positive sign and is significant. This suggests that as the home country grows it increases the demand for M&As into other countries, which is consistent with my expectation. The coefficients on the stock market capitalization variable and the domestic credit variable are both significant and positive. These results suggest that financial deepening (i.e. increase in the size of financial markets) in the home country increases the cross-border M&A activities. These results are consistent with Di Giovanni's (2005) results. The coefficient on the exchange rate variable is significant and has the expected negative sign as well. The coefficient on the distance variable is negative and significant, which suggests that increase in the distance between the home and the host countries decreases the M&A activities between the two countries. This result is consistent with the gravity model in the trade literature. The coefficient on the common language usage dummy variable is positive and significant, which suggests that common language usage increases the M&A activities between the home and the host countries. This result is similar to the gravity model, which states that cultural similarity between the two countries increases trade and FDI. The coefficient on the dummy variable To Colony and the coefficient on the dummy variable From Colony are positive and significant. These results again suggest that cultural similarity does have positive impact on the cross-border M&A activities. Finally, the coefficient on the common regional trade agreement (RTA) variable is positive and significant, which suggests that there are more cross-border M&A activities between the countries that are in the same trade agreement.

5.3.1. *Robustness checks*

In this section, I discuss further robustness checks of the results. First, Blonigen has suggested that mergers and acquisitions data from SDC Platinum before 1990 are not very clean for some countries (e.g. Germany, France). Thus, I estimate equation (17) using the data from 1990 to 2007. The first column of table 3 shows the results. The coefficient on the interaction term is still significant and has the expected sign. The magnitude of the coefficient is also similar to the estimation coefficient in table 2. In fact, most coefficients on other variables also have the same signs as the estimation coefficients in table 2, and the magnitude is very similar as well.

Second, I examine alternative measures to proxy for indicating the importance of the technology in an industry. I construct a high-tech share for each industry where high-tech share measures the share of assets in an industry that are considered high technology in nature. I follow Feenstra and Hanson's (1999) method in constructing the high-tech share. I categorize industries as high-tech industries if an industry's high-tech share is at or above the mean of the total industry high-tech share. Table 3, column two, shows estimation results of equation (17) using this alternative measure for *tech*. The coefficient for the interaction term is significant and has the expected sign. The magnitude is also quite similar to the coefficient in table 2. Most coefficients on other variables also have the same signs as the estimation coefficients in table 2, and the magnitude is very similar as well. This suggests that my results are robust to other measures of technology-seeking motive.

Third, the industries in my data set are classified by the SIC code of the target, but the target's SIC code and acquirer's SIC code are often not the same. Thus, one might question whether an acquisition of a target in a high R&D industry by an acquirer in a low R&D industry should be considered as technology-seeking. In order to make sure that I am really capturing technology-seeking motive with the *tech* dummy, I look at a subsample of cross-border M&A where the target's SIC code and acquirer's SIC code are the same. Table 3, column three, presents the results. The coefficient on the interaction term is significant and has the expected sign. In fact, the magnitude is slightly higher than the estimation coefficient from table 2. This is probably because cross-border M&As in high R&D industries are now less noisy and just include the technology-seeking motives. Thus, the result supports my prediction from the theory. Again, most coefficients on other variables have the same signs as the estimation coefficients in table 2, and the magnitude is very similar as well.

Fourth, I check to see whether my results are sensitive to the 10% threshold level I use to define an acquisition. I perform regressions on equation (17) using two different dependent variables constructed by using 50% and 100% as the threshold level. The main coefficient is still significant and has the expected sign for both cases. Thus, the result doesn't seem to be sensitive to threshold levels used to construct the dependent variable.

Lastly, since I have panel data, the standard errors should be clustered. However, standard errors cannot be clustered in the negative binomial model for panel dataset in a way that is similar to standard regression models. Thus, I perform bootstrap with a cluster option instead on equation (17). I perform bootstrap estimation, with clustering on industry and country pair. Estimation results show that the main coefficient (i.e. the coefficient on the interaction term) is still significant at the 1% level.

6. CONCLUSIONS

Cross-border M&A has been growing fast over the past couple of decades and has been the major source of FDI. I build a model of cross-border M&A and provide empirical evidence of the model in this paper to enhance our understanding of cross-border M&A.

There are two main contributions of this paper. The first is the incorporation of the technology-seeking motive into a M&A model where technologies yield synergy gains. I show that there are distinct productivity cutoffs in the model that separate exporting, greenfield FDI, technology-seeking cross-border M&A, and market-seeking cross-border M&A in equilibrium and show how different firm types sort into these foreign market access modes.

Second, I show that the model generates a sharp theoretical distinction between the two cross-border M&A motives. In particular, proportionately more firms engage in technology-seeking cross-border M&A as their home country's size increase relative to the host country, whereas the opposite is true for market-seeking cross-border M&A. I use this prediction of the model to come up with an estimation strategy to identify the technology-seeking motive in the data. I provide evidence of this result by showing that the cross-border M&A into high-R&D sectors in the host country increases as the relative size difference between the home and the host country (i.e. home country size minus host country size) increases.

The primary focus of this paper is to better understand cross-border M&A by building a theoretical model. However, some welfare and policy implications still can be drawn from the results of my model. When firms engage in technology-seeking cross-border M&A they reach a new level of productivity due to synergy gain. Thus, new differentiated products that are produced at a new productivity level are introduced to the economy. This can be interpreted as a welfare gain in a CES preference setting where there are gains from variety.

As for policy implications, there have been some concerns about hostile takeovers of domestic firms by foreign firms to get technology. Further development of my model could provide deeper understanding of these M&A activities by foreign firms and several issues that are of concern to the policy makers. Also, if we think solely from the gains from a variety perspective, cross-border M&A may increase welfare of the consumers by increasing the number of products in the economy, which is an important implication for policy makers.

The theoretical model, I develop in this paper is somewhat limited in the sense that it is a static model, whereas in the real world acquisition process, synergy realization and integrating market-specific expertise occur over a period of time. Thus, future research will look at developing dynamic models of M&A activity.

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Table 1. Descriptive statistics 1985-2007

Variable	Obs	Mean	Std. Dev.	Min	Max
# of acquisition by foreign firms	18769380	0.003	0.082	0	45
Size difference (home minus host)	18769380	0	2.068	-6.798	6.798
Home country's real GDP growth rate	18769380	2.961	2.633	-11.89	11.28
Logged exchange rates	15410670	5.62e-09	3.404	-12.611	12.611
Stock market capitalization to GDP	15589560	65.755	56.202	0.188	479.742
Domestic credit to GDP	18234720	86.189	49.077	11.114	319.468
Distance	18769380	3330.293	3344.478	107.504	12327.05

Table 2. Country size difference and technology-seeking cross-border M&A, 1985-2007

Variables	Negative binomial	Incidence Rate Ratio	Negative binomial
Interaction of size difference and *tech* dummy	0.124***	1.132***	0.150***
	(0.008)	(0.009)	(0.009)
Size difference (home minus host)	0.716***	2.046***	0.693***
	(0.004)	(0.008)	(0.005)
tech dummy	-	-	-
	-	-	-
Home country's real GDP growth rate	-	-	0.034***
	-	-	(0.003)
Logged exchange rates	-	-	-0.142***
	-	-	(0.003)
Stock market capitalization to GDP	-	-	0.003***
	-	-	(0.0001)
Domestic credit to GDP	-	-	0.004***
	-	-	(0.0002)
Distance	-	-	-0.0002***
	-	-	(0.000004)
Language	-	-	0.851***
	-	-	(0.014)
To Colony	-	-	0.495***
	-	-	(0.020)
From Colony	-	-	0.378***
	-	-	(0.023)
RTA	-	-	0.660***
	-	-	(0.022)
Industry and Time FE	Yes	Yes	Yes
Observations	1,034,264	1,034,264	892,083

Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3. Country size difference and technology-seeking cross-border M&A

Variables	1990-2007 Negative binomial	High-tech share Negative binomial	Same target and acquirer SIC Negative binomial
Interaction of size difference and *tech* dummy	0.148***	0.121***	0.228***
	(0.009)	(0.009)	(0.016)
Size difference (home minus host)	0.694***	0.702***	0.671***
	(0.005)	(0.005)	(0.009)
tech dummy	-	-	-
	-	-	-
Home country's real GDP growth rate	0.034***	0.034***	0.032***
	(0.003)	(0.003)	(0.006)
Logged exchange rates	-0.139***	-0.142***	-0.118***
	(0.003)	(0.003)	(0.005)
Stock market capitalization to GDP	0.003***	0.003***	0.003***
	(0.0001)	(0.0001)	(0.0002)
Domestic credit to GDP	0.004***	0.004***	0.003***
	(0.0002)	(0.0002)	(0.0003)
Distance	-0.0002***	-0.0002***	-0.0002***
	(0.000005)	(0.000004)	(0.000008)
Language	0.879***	0.848***	0.984***
	(0.014)	(0.014)	(0.026)
To Colony	0.469***	0.496***	0.457***
	(0.020)	(0.020)	(0.037)
From Colony	0.369***	0.376***	0.328***
	(0.024)	(0.023)	(0.044)
RTA	0.609***	0.659***	0.619***
	(0.023)	(0.022)	(0.041)
Industry and Time FE	Yes	Yes	Yes
Observations	855,216	892,083	292,886

Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%

Table 4. Number of foreign acquisitions into U.S. in Manufacturing and Non-manufacturing sectors and the ratio, 1985-2007

	Manufacturing	Non-manufacturing	Ratio (Manufacturing/Non-manufacturing)
Australia	165	371	0.44
Canada	1069	2309	0.46
France	345	337	1.02
Germany	421	339	1.24
Japan	556	358	1.55
United Kingdom	1421	1844	0.77

Source: SDC Platinum

Figure 1. Profits of each entry mode and thresholds

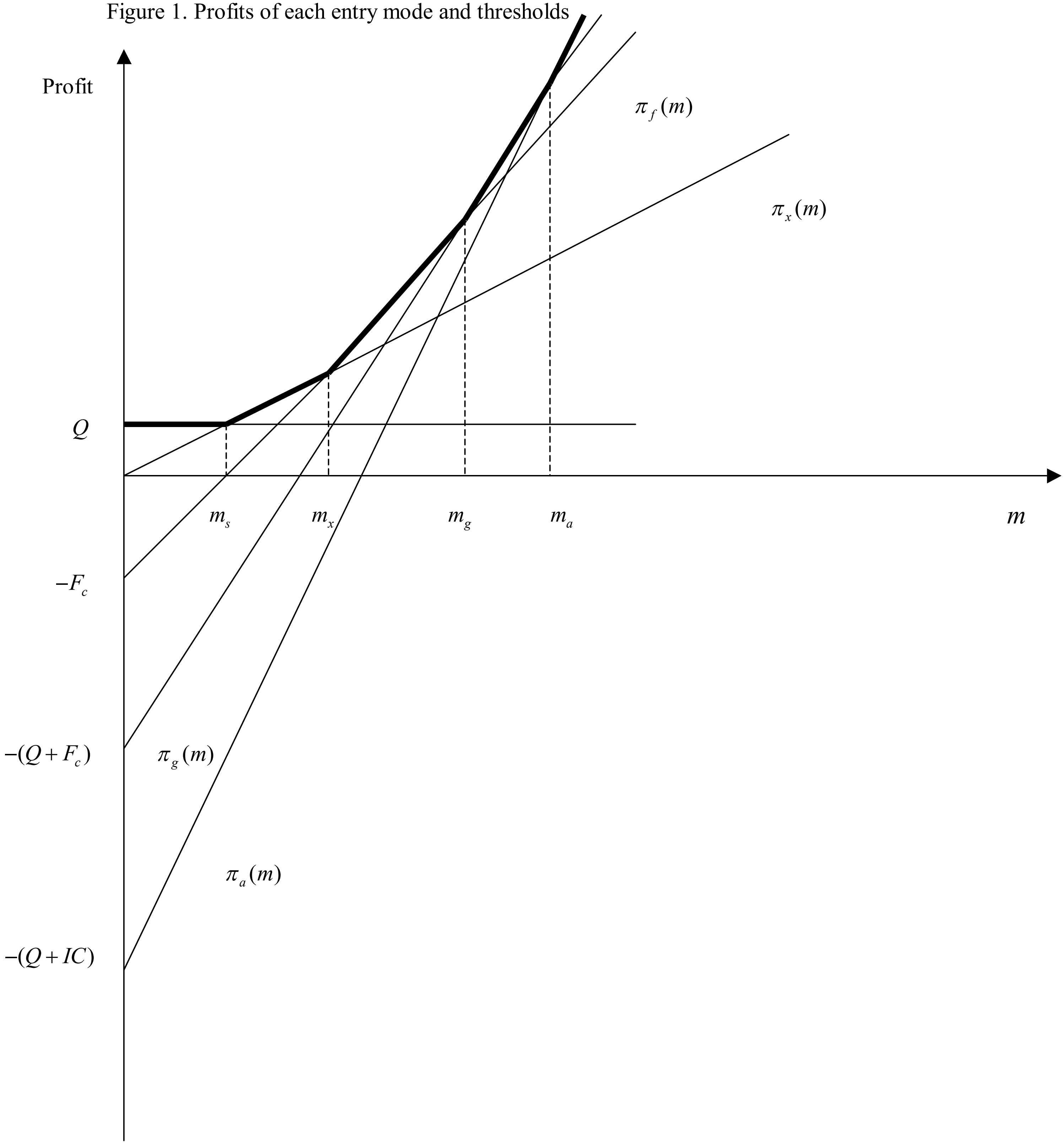


Figure 2. Directions of the thresholds' movements as countries become asymmetric

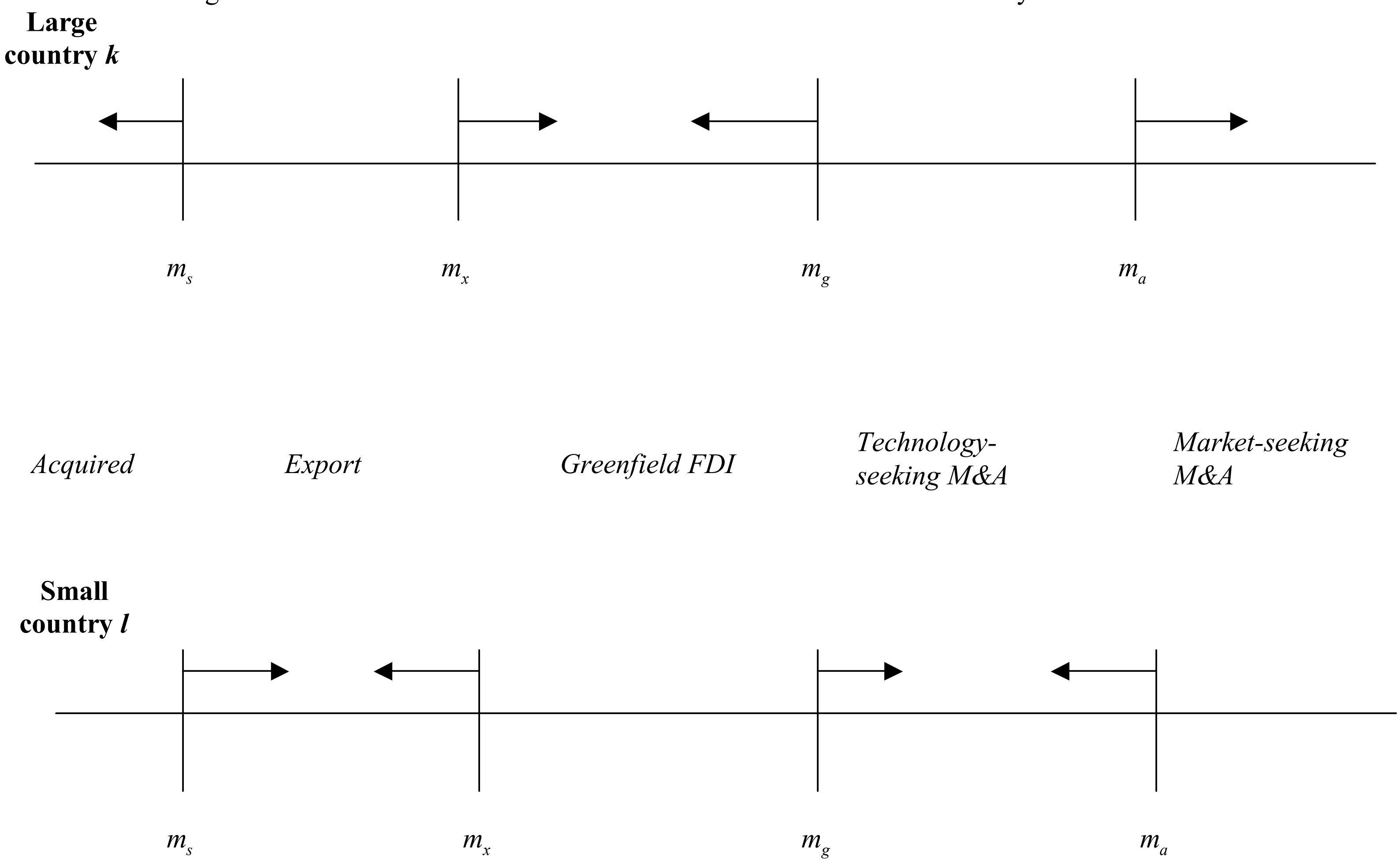
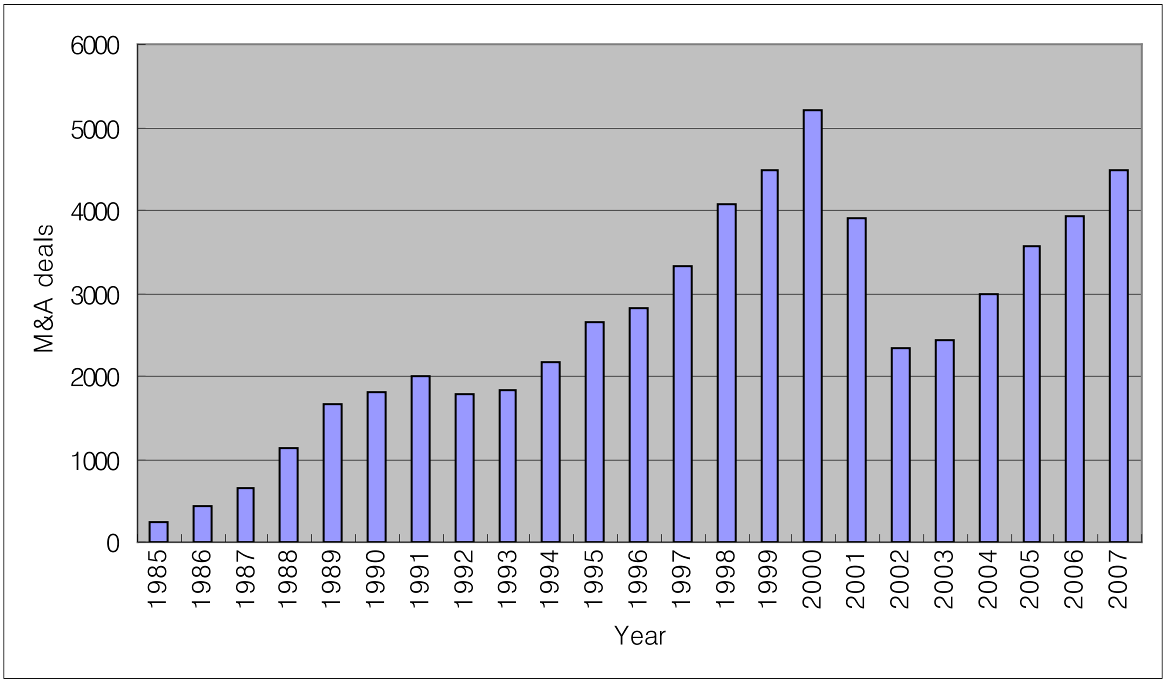


Figure 3. Cross-border M&A Deals of the OECD Countries, 1985-2007



APPENDIX A

1. DISCUSSION ON THE SYNERGY EFFECT

The synergy is realized because the target firm from another country has a technology that is different from the acquirer. In this case, the target's technological capability does not have to be necessarily more advanced or more efficient than the acquirer, for the synergy to be realized. As long as the target's technological capability gives a different perspective on producing the product unknown to the acquirer, then this could be useful information and thus cross-border M&A will take place to obtain the synergy effect. Evidence of synergy effect from cross-border M&A can be found from the following articles (see, for example Morosini *et al* (1998), Vermeulen & Barkema (2001), and Gertsen *et al* (1998)). Empirical papers from international trade literature also suggest possible synergy realization coming from cross-border M&A (see, for example Branstetter (2000) and Takechi (2006)).

2. SYNERGY DEPENDENT ON TARGET'S TECHNOLOGICAL CAPABILITY

In my model I assume that the synergy effect *g,* coming from acquiring target firm's technological capability is constant. It might sound more realistic if *g* depends on target firm's technological capability. However, I will show that even if *g* depends on target firm's technological capability it will not change the equilibrium outcome as long as acquirer can't observe target firm's technological capability. Assuming that the acquirer doesn't know the true value of the target's technological capability is not so far fetched compared to the real world because even in the real world, the acquirer cannot know the true value of the target.

I'll assume that *g* is a function of *m* where $g(\cdot)$ increase as *m* increase. I'll also assume that $g(\underline{m})$ is greater than 1 where $\underline{m}$ is the lowest value of *m* (this is to insure that expected value of $g(m)$ is greater than 1)[23]. Then the actual profit realized for the acquirer from synergy will depend on $g(m)$ but when acquirer makes a cross-border M&A decision, they will base it on the expected profit generated from getting expected synergy, i.e. $E(g(m) \mid m < m_s)$. This expected value is constant and is equal to all potential acquirers so their decision making process will be identical to having a constant synergy *g*. Thus, the equilibrium outcome will look identical too.

3. CULTURAL DISTANCE AND INTEGRATION COST

Integration cost of cross-border M&A is the subject of an extensive literature. For example, when firms from different countries merge, a lot of the time they fail the integration process due to conflicts caused by cultural differences (See, for example, Finkelstein (1999), Zhu and Huang (2007), Drogendijk and Slangen (2006)). Thus, I assume that integrating target firm's capabilities into the acquiring firm is costly for cross-border M&A and this integration cost is more costly for market-specific expertise than technological capability. Technological capability is transferred directly upon acquisition and no *IC* needs to be spent to realize the synergy effect.

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[23] This is sufficient condition to insure that M&A takes place in equilibrium. If expected synergy effect is less than one it is possible that M&A won't take place because it can actually harm your productivity.

The intuition behind this is based on the assumption that technological capability is readily transferable. For example, transferring technological capability can be as simple as just sending the blue prints to a specific technology from the target firm to the acquiring firm. Cultural barrier shouldn't have any affect on this process but for market-specific expertise, since it represents knowledge on local marketing strategy, local market condition, and local tastes, overcoming the cultural barrier and understanding the target firm's local culture is crucial to the acquirer if it wants to fully utilize market-specific expertise. Thus, I assume in my model that acquiring firm must incur *IC* if it wants to fully integrate the target firm's market-specific expertise, but no *IC* is necessary for integrating the technological capability. In the next section, I present a descriptive statistical evidence of my argument.

3.1. *Descriptive statistical evidence*

Table 4 shows the number of acquisitions made by foreign firms into United States[24]. As we can see from the table, France, Germany and Japan made more acquisitions in manufacturing sector than in non-manufacturing sector whereas Australia, Canada and United Kingdom made more acquisitions in non-manufacturing sector. If we look at the ratios of number of acquisitions in manufacturing to non-manufacturing, it becomes more evident that France, Germany and Japan were more active in manufacturing sector's M&A market and Australia, Canada and United Kingdom were more active in non-manufacturing sector's M&A market. This suggests that since R&D expenditure is much higher in

[24] Acquisition data are from SDC platinum.

manufacturing sector than in non-manufacturing sector, French, German and Japanese firms' motives were generally to acquire technological capability whereas the Australian, Canadian, and British firms' motives were generally to acquire market-specific expertise. Australia, Canada, United Kingdom, and United States speak the same language and are known to share similar culture. On the other hand, France, Germany, and Japan do not speak the same language as in United States and their cultures are not as similar to United States as the former group. This stark distinction is quite surprising if we assume integration cost for both capabilities is homogeneous.

If we assume cultural difference between the two merging firms imply high *IC* for market-specific expertise relative to technological capability the result of this table is not so surprising. For Australia, Canada and United Kingdom, *IC* that the firms have to incur after acquiring market-specific expertise would be relatively low since cultural distance with United States is relatively small, thus it wouldn't be much difficult for them to integrate the market-specific expertise of the target firm. But for firms from France, Germany, and Japan, this *IC* would be pretty high causing them to prefer technological capability driven acquisition, which does not require high *IC*. Thus, the summary statistics provide some evidence for heterogeneous integration cost between the two capabilities.

APPENDIX B

PROOF OF LEMMA 1.

This is the proof shown in Nocke and Yeaple (2004). The endogenous variable u in country k may be written as a function of the country sizes, $f(Y^k, Y^l)$, where the first argument refers to the own country size, and the second argument to the size of the other country. Assuming differentiability of *f* (which can be verified to hold for our problem at hand), the endogenous change in the value of u^k is given by

$du^k = f_1(Y^k, Y^l)dY^k + f_2(Y^k, Y^l)dY^l$, where f_i is the derivative of *f* with respect to its *i*th argument. Similarly, the endogenous change in the value of

$du^l = f_1(Y^l, Y^k)dY^l + f_2(Y^l, Y^k)dY^k$. Since $Y^k = Y^l$, we have $f_i(Y^k, Y^l) = f_i(Y^l, Y^k)$.

Moreover, by assumption, $dY^k = -dY^l$, and so

$du^l = -f_1(Y^k, Y^l)dY^k - f_2(Y^k, Y^l)dY^l = -du^k$.

PROOF OF PROPOSITION 2.

I use similar proof method used in Nocke and Yeaple (2004) to prove Proposition 2. From the market clearing condition (13), we know that $H(m_s) = 1 - H(m_g)$. So the merger market clearing condition $E^k(1 - H(m_g^k)) = E^l H(m_s^l)$ (*k* stands for the large country and *l* stands for the small country; $E^k = E^l$ and the thresholds in country *k* and *l* are the same when the two countries are identical) can be written as $E^k H(m_s^k) = E^l H(m_s^l)$.

Taking the logarithm of the merger market clearing condition and taking the total derivative yields,

$$\frac{dE^k}{E^k} + \frac{h(m_s^k)dm_s^k}{H(m_s^k)} = \frac{dE^l}{E^l} + \frac{h(m_s^l)dm_s^l}{H(m_s^l)}$$

Using Lemma 1 and the fact that countries were identical before the change in *Y*, this equation can be written as

$$\frac{dE^k}{E^k}+\frac{h(m_s^k)dm_s^k}{H(m_s^k)}=-\frac{dE^k}{E^k}-\frac{h(m_s^k)dm_s^k}{H(m_s^k)}$$, which simplifies to

$$\frac{dE^k}{E^k}=-\frac{h(m_s^k)dm_s^k+h(m_s^k)dm_s^k}{2H(m_s^k)} \tag{18}$$

Now I will look at the free entry condition from equation (12) for country k, which is $\int_0^\infty V^k(m)dH(m)-F_e=0$.

This can be written as:

$$\int_0^{m_s^k} Q^k dH(m)+\int_{m_s^k}^{m_x^k}(S^k m+S^l T\delta m)dH(m)+\int_{m_x^k}^{m_g^k}(S^k m+S^l\delta m-F_c)dH(m)+$$
$$\int_{m_g^k}^{m_a^k}(S^k mg+S^l\delta mg-Q^l-F_c)dH(m)+\int_{m_a^k}^{\infty}(S^k mg+S^l mg-Q^l-IC)dH(m)=F_e$$

I'm going to define $\Psi(m_i)\equiv\int_{m_i}^{\infty} mdH(m)$.

And simplify the free entry condition as,

$$Q^k H(m_s^k)+S^k\Psi(m_s^k)-S^k\Psi(m_g^k)+S^k g\Psi(m_g^k)+S^l T\delta\Psi(m_s^k)-S^l T\delta\Psi(m_x^k)+S^l\delta\Psi(m_x^k)-S^l\delta\Psi(m_g^k)+$$
$$S^l\delta g\Psi(m_g^k)-S^l\delta g\Psi(m_a^k)+S^l g\Psi(m_a^k)-F_c(H(m_a^k)-H(m_x^k))-Q^l(1-H(m_g^k))-IC(1-H(m_a^k))=F_e$$

Now take total derivative of this expression and applying Lemma 1:

$$dQ^k(H(m_s^k)-H(m_g^k)+1)+$$
$$dS^k[\Psi(m_s^k)+(g-1)\Psi(m_g^k)-T\delta\Psi(m_s^k)-(1-T)\delta\Psi(m_x^k)-(g-1)\delta\Psi(m_g^k)-(1-\delta)g\Psi(m_a^k)]=0$$

Note that $dm_i^k=0$ due to the envelope theorem and the fact that the thresholds are efficient from the firms' point of view in that they maximize (expected) profits.

Also, note that $(H(m_s^k)-H(m_g^k)+1)$ is positive

and

$[\Psi(m_s^k)+(g-1)\Psi(m_g^k)-T\delta\Psi(m_s^k)-(1-T)\delta\Psi(m_x^k)-(g-1)\delta\Psi(m_g^k)-(1-\delta)g\Psi(m_a^k)]\equiv\Gamma>0$

because $\Psi(m_s^k)>\Psi(m_x^k)>\Psi(m_g^k)>\Psi(m_a^k)$.

Therefore, I can conclude that dQ^k and dS^k has opposite signs, i.e. they move in the opposite direction.

Now I will take logs and then take total derivatives of the threshold equations:

$$m_s^k=\frac{Q^k}{S^k+S^lT\delta},\ m_x^k=\frac{F_c}{S^l\delta(1-T)},\ m_g^k=\frac{Q^l}{(S^k+S^l\delta)(g-1)},\ m_a^k=\frac{IC-F_c}{S^l(1-\delta)g}.$$

Taking total derivatives and appealing to Lemma 1, I get the following conditions:

$$\frac{dm_s^k}{m_s^k}=\frac{dQ^k}{Q^k}-\frac{(1-T\delta)dS^k}{(1+T\delta)S^k}\ ,\ \frac{dm_x^k}{m_x^k}=\frac{dS^k}{S^k},\ \frac{dm_g^k}{m_g^k}=-(\frac{dQ^k}{Q^k}+\frac{dS^k(1-\delta)}{S^k(1+\delta)}),\ \frac{dm_a^k}{m_a^k}=\frac{dS^k}{S^k}.$$

We can see from this that dm_s^k moves in the opposite direction as dS^k and dm_x^k and dm_a^k move in the same direction as dS^k. Therefore, we can also conclude from equation (18) that dE^k and dS^k move in the same direction. However, dm_g^k can be ambiguous because if dS^k increase dQ^k will decrease so it is not clear how dm_g^k will move as dS^k increase. Thus it will depend on the magnitude of dS^k and dQ^k.

Let's first assume that price *Q* does not adjust at all with a change in *Y*. Then dQ^k will equal zero and dm_g^k and dS^k will move in the opposite direction. Thus, as long as dQ^k change by a small ε amount, dm_g^k and dS^k will still move in the opposite direction and

Proposition 2 will hold. Therefore, price Q needs to be inelastic and does not change much with a change in Y.

Lastly, I will look at $S^k = \frac{\alpha Y^k}{\sigma(\rho P^k)^{1-\sigma}}$ which is also equal to

$$S^k = \frac{\alpha Y^k}{\sigma \rho^{2(1-\sigma)}} \{E^k[\Psi(m_s^k) + (g-1)\Psi(m_g^k)]$$
$$+E^l[T\delta\Psi(m_s^l) + (1-T)\delta\Psi(m_x^l) + (g-1)\delta\Psi(m_g^l) + (1-\delta)g\Psi(m_a^l)]\}$$

By taking logarithm and taking total derivative I get the following equation:

$$\frac{dS^k}{S^k} + \frac{\frac{dE^k}{E^k}\Gamma + \{(1-T\delta)\Psi'(m_s^k)dm_s^k + (g-1)(1-\delta)\Psi'(m_g^k)dm_g^k - (1-T)\delta\Psi'(m_x^k)dm_x^k - (1-\delta)g\Psi'(m_a^k)dm_a^k\}}{(1+T\delta)\Psi(m_s^k) + (1-T)\delta\Psi(m_x^k) + (g-1)(1+\delta)\Psi(m_g^k) + (1-\delta)g\Psi(m_a^k)}$$
$$= \frac{dY^k}{Y^k}$$

Since $\Psi'(m_i) < 0$, the term in curly brackets has the same sign as dS^k and dE^k. Hence it must be the case that when dY^k is positive dS^k is also positive implying that they move in the same direction. Therefore, if there is a small increase in the size of country k and a small decrease in the size of country $l \neq k$ such that $dY^k = -dY^l > 0$, then $dS^k = -dS^l > 0$, and $dm_s^k = -dm_s^l < 0$, $dm_x^k = -dm_x^l > 0$, $dm_g^k = -dm_g^l < 0$, and $dm_a^k = -dm_a^l > 0$.