Technology Transfer and Competition: Does Mode of Foreign Entry Matter?

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1. Introduction

There is a long time belief that benefits to host country from foreign investment is greater under greenfield compared to mergers and acquisition (M&A). It is argued that greenfield brings in additional capital, contributing to new capital formation, technology transfer and employment whereas M&A simply means a change of ownership. Greenfield also increases competition while M&A reduces competition. This belief is reflected in policy that discriminates in favor of greenfield investment, but against M&A. For example, tax exemption allowed for green field investment, but not for M&A.

The impact of greenfield investment and M&A is clear with respect to competition, but what about the impact on technology transfer? It is not so clear a priori, why technology transfer should be greater, and therefore the benefits of the host country be greater under greenfield. The UNCTAD (2000) survey suggests there may not be such a great difference between modes of FDI in the long run. Follow on investment, technology transfer and employment generation can be high for the acquired firm. In a study of OECD countries over the period 1990-1999, Bertrand and Zuniga (2006) shows that cross-border M&As did not necessarily stifle host country R&D, and that while domestic M&As stimulated R&D investment in low-technology intensive industries, cross-border M&A tended to stimulate R&D investment in medium

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2 It is not even clear with respect to competition. Sometimes, M&A can encourage competition by bringing in new entrant into the domestic economy, or by preventing an existing player from exiting the market (Yun 2001).
technology intensive industries.

There is not much literature exploring this issue either theoretically or empirically. Mattoo, Olarreaga and Saggi (2004) is almost the only theoretical treatment of how technology transfer may differ between different modes of foreign direct investment entry. Mugele and Schnitzer (2008) consider the interplay between distances, technology and ownership structure (full ownership versus joint venture) but do not consider mode of FDI entry. Nocke and Yeaple (2007) analyse mode of entry decision in the case of firm heterogeneity (mobile versus immobile firms), but do not consider technology transfer issue related to mode of entry. Similarly, Raff, Ryan and Stahler (2008) explore choice of entry mode between greenfield, M&A, and additionally joint ventures, but do not consider technology transfer issues. As discussed above, Bertrand and Zuniga (2006) studied the differential effect of domestic and cross-border M&As on R&D activity, rather than the difference between FDI modes of entry. This paper examines Mattoo, Olarreaga and Saggi (2004)’s model and attempts to empirically test some of their results.

2. The Model

In Mattoo, Olarreaga and Saggi (2004)’s model, the incentive to transfer technology differs between modes of entry, depending on the degree of competition and the cost of technology transfer. The foreign firm first decides on whether to enter through mergers or through greenfield, depending on which provides the greater profit. The foreign firm has to weigh the price at which acquisition occurs against the gain competition reduction brings. If the latter is higher, the firm enters through mergers.

Otherwise, profit under greenfield is greater and the firm enters through greenfield investment. It should be noted that the buyout price depends on the amount of technology transfer. When transfer cost is high (technology transferred is low), the profits of domestic firms are higher and the buyout price for the target firm is higher. This makes M&A less profitable and greenfield entry is more likely. On the other hand, when transfer cost is low (technology transferred is high), the profits of domestic firms are lower, and the buyout price decreases. This makes M&A more profitable and M&A entry is more likely.

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3 For greater detail on the model, see Appendix.
However, when the transfer cost is high, the actual incentive to transfer technology may be higher under M&A than greenfield entry. The actual level of technology transfer is determined by a complex interplay between the cost of technology transfer and the level of competition. Solving for the optimal level of technology, Mattoo et al (2004) show that above a critical level of technology transfer cost, the incentive to transfer technology is greater under M&A than greenfield.

The incentive to transfer technology differs between the modes of entry because the optimal technology transfer depends not only on the trade off between the cost of transfer and the gains (profit increase due to cost reduction), but also on the level of competition (number of firms)\(^4\). The latter effect is due to the strategic motive for technology transfer. When the level of technology transfer is decided before quantities, firms have strategic incentives in deciding on technology transfer. This is because technology transfer not only increases profit due to own cost reduction, but also through lowering the quantities of competing firms.

Mattoo et al shows that the strategic effect increases with competition up to a certain critical level, and then decreases with competition thereafter. That is, when the market is highly concentrated, there is little room for strategic interaction, and the strategic effect has little impact. Under oligopolistic market, the strategic effect becomes more important, but as the market approaches perfect competition levels, strategic effect again disappears. Therefore, the strategic incentive to transfer technology is higher under greenfield than M&A when competition level is low (since competition increases with greenfield), but it is higher for M&A when competition level is high (competition decreases with M&A).

On the other hand, the strategic effect is decreasing in the cost of technology transfer, because the strategic effect is proportional to the foreign firm’s output, and the output declines with technology transfer cost (since high costs mean lower transfer, and lower profits). Therefore, when technology transfer cost is low (technology transfer level is high), strategic effect is strong. This means the effect of competition on technology transfer decision becomes greater, so that the strategic incentive to transfer technology is higher under greenfield (when number of firms are greater). This implies that the technology transfer under green field entry is greater when the level of competition is low, especially when technology transfer cost is low.

\[^{4}\] Under M&A, the number of firms is always less than the number of firms under greenfield.
Predictions from the model are summarized in Table 1. When technology transfer cost and the degree of competition is low, incentive to transfer technology is greater under green field entry than M&A. But profits are higher under M&A, and M&A is more likely to occur than greenfield. When transfer cost is high and the degree of competition is high, the incentive to transfer technology is greater under M&A than greenfield, but the profits are greater under greenfield and M&A is less likely to occur. In the next section, these predictions are empirically tested, using Korean FDI data for the period 2000-2004.

Table 1. Effect of Technology Transfer Cost and Competition on Mode of Entry

<table>
<thead>
<tr>
<th>Technology Transfer (x)</th>
<th>Low transfer cost, Low competition</th>
<th>High transfer cost, High competition</th>
</tr>
</thead>
<tbody>
<tr>
<td>GF &gt; MA</td>
<td>MA &gt; GF</td>
<td></td>
</tr>
<tr>
<td>MA &gt; GF</td>
<td>GF &gt; MA</td>
<td></td>
</tr>
</tbody>
</table>

3. Empirical Analysis

3.1. Hypotheses and Variables

Using data on FDI flowing into Korean manufacturing sector during 2000-2004, this paper tests two related hypotheses which follow directly from the theoretical framework discussed in the preceding section. The model predicts that profit is higher for M&A when technology transfer cost is low and concentration is high. Therefore this is when M&A is more likely to be found. On the other hand, profit is higher for green field investment when technology transfer cost is high (and concentration is low), and therefore this is when greenfield is more likely to be found.

*Hypothesis 1:* M&A is more likely to occur when technology transfer cost is low, and when competition is low (or when concentration is high). Therefore, M&A is positively correlated with low transfer cost and concentration.
This hypothesis can be tested through a logit model such as the following:

\[ Y = a + b_1 \cdot \tau + b_2 \cdot COMP + e \]

where \( Y = 1 \) if \( \Delta \pi > 0 \) (M&A)
\( = 0 \) if \( \Delta \pi < 0 \) (greenfield).

The dependent variable \( Y \) is a dummy variable taking the value of 1 if mode of entry is M&A and 0 when mode of entry is greenfield. The underlying determinant of \( Y \) is the profit difference between the two modes of entry, \( \Delta \pi = \pi_{M&A} - \pi_{greenfield} \). The profit difference is explained by the level of technology transfer cost, \( \tau \) and the level of competition \( COMP \). The level of the inverse of competition is measured by the three-firm concentration ratio, \( CR3 \). This variable should be positively correlated with \( Y \).

The cost of transferring technology is difficult to measure directly. Technology can be transferred to the subsidiary in many different forms, including technical documentation, education and training of the affiliate labor force, exchange of technical personnel, shipments of machinery and equipment, and on-going communication to solve problems. (Kokko and Blomstrom, 1995). Some of the costs incurred during these transferring activities are borne by the foreign firm, while some of the cost is borne by the domestic firm in the form of learning (Wang and Blomstrom, 1992). Not all of these transfers are recorded and not all of them are “priced” at market rates. Therefore it is difficult to measure the extent or the amount of technology transferred in the first place, and in the second place, the cost incurred during the transfer process. In a cross-country study, Kokko and Blomstrom (1992) uses country characteristics (such as level of competition and education, performance requirements regulations on FDI) as determinants of transfer cost that affects the level of technology transferred (measured by capital imports and license fees and royalties).

The cross-country technique cannot be used here, and information on possible proxies for transfer cost such as the budget for education and training, or travel costs of dispatched technical personnel, is not readily available. Here, two different proxies are used. First, capital intensity (fixed asset divided by number of employees) is used as a proxy for technology transfer cost. Technologies that are complex, automated and difficult to learn would be more difficult to transfer and entail greater cost. This kind of
technology also tend to be highly capital intensive. This proxy is represented by the variable $CAPIN$.\(^5\)

Another proxy is high technology industries. Instead of the cross-country tactic, here different industry characteristics are made use of. Firms operating in high tech industries would face greater technology transfer cost because technologies used in these industries are advanced, frontier technologies. This proxy is represented by the dummy variable $HITECH$, taking the value of 1 for chemicals (including pharmaceutical and rubber), electric and electronics, machineries, precision equipments, and transportation equipments. Both the technology transfer cost proxies should be negatively correlated with $Y$.

The second prediction is that incentive to transfer technology, and therefore the amount of technology transferred under M&A is greater than it is for greenfield entry when technology transfer cost is high, and when competition level is high. The underlying reason for this phenomenon is due to the strategic incentive to transfer technology being a function of technology transfer cost and competition. The strategic effect is decreasing in the technology transfer cost. At the same time, the strategic effect is first increasing in competition but after a critical level, decreasing in competition, as competition level rises.

*Hypothesis 2:* The strategic effect is negatively correlated with technology transfer cost, and is non-linearly correlated with competition. It first increases with competition but then decreases with competition as competition levels rise.

This hypothesis can be tested by the following OLS model:

$$S = a + b_0 \cdot \tau + b_1 \cdot COMP + b_2 \cdot COMP^2 + e,$$

where the dependent variable $S$ represents the strategic effect, $\tau$ is again the technology transfer cost, and $COMP$ represents level of competition. The third variable $COMP^2$ is the quadratic term for competition, and $e$ is the error term. Strategic effect refers to the effect of increase in the foreign investing firm’s profit, through the decrease in domestic firm’s output (which would also mean increase in the output of the foreign firm) as a result of the foreign firm’s technology transfer. This is measured by two

\(^5\) In Mattoo et al’s model, the technology transfer cost $C(x)$ is proportional to both $\tau$ and $x$. 
proxies. The first proxy $SCHANGE$, measures the ratio of change in the sales (ie, output) divided by the change in capital intensity after FDI takes place. Change in capital intensity is a proxy for the amount of technology transferred. If greater proportion of tangible and intangible capital is used after foreign investment compared to before the investment, one could conclude that technology has been transferred. The second proxy $NPATCHANGE$ measures the ratio of change in the net profit after tax to the change in capital intensity after FDI takes place.

The variables reflecting changes from before the investment to after the investment (change in sales, change in net profit after tax and change in capital intensity) are constructed by subtracting the value of the variable existing at the time of first entry from the value of the variable in 2004. When data on the variable is missing, data of nearest years are used, as long as the difference represents capital intensity difference before and after the investment. For FDI entering in 2004, the difference is from 2003. Since all FDI taking place in 2004 are M&A, the value in 2003 represents the value of the variable for the target domestic firm before the acquisition is made, and the value in 2004 represents the value of the variable when foreign investment takes place.

Since change in capital intensity is now being used as a proxy for the actual technology transfer rather than change in the transfer cost, the technology transfer cost variable $\tau$ is here proxied only by $HITECH$. Competition is measured by $(1/CR3)$. According to the second hypothesis, the coefficient $b_0$ should be negatively signed, $b_1$ positively signed, and $b_2$, negatively signed.

3.2 The Data.

The sample data consists of 38 foreign direct investment cases in manufacturing industries, occurring during 2000-2004. The mode of entry data is acquired from a rare survey undertaken by Lee and Yun (2006). Evidence has been collected from as many sources as possible, including annual corporate financial statements, press articles, and interviews with corporate personnel actually involved in making the deals to ascertain the mode of entry. A mode of entry is greenfield when a new business is established, making new investment in fixed asset such as manufacturing facilities and equipment. M&As are those acquiring existing stocks and when new stocks are issued by the target firm to foreign investors. The non-M&A category includes mode of entry known as purchase and assumption (P&A). In this case, a company is newly established but the
new firm acquires existing business operations and assets of an existing, target firm. Therefore the form of entry is closer to greenfield but the motivation behind the investment is closer to M&A. Of the 38 cases in the sample, 19 cases are categorized as M&A.

Financial data such as total assets, sales, employment, and net profit after tax are acquired from the Corporate Financial Statement, which these firms are obliged to disclose electronically in the Financial Supervisory Services website. The concentration data comes from Korea Development Institute (2003). Table 2 shows a summary statistics of the main variables.

### Table 2. Summary Statistics of Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. Obs.</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment amount ($1000)</td>
<td>38</td>
<td>89,003.26</td>
<td>118,525.4</td>
<td>11,222</td>
<td>498,822</td>
</tr>
<tr>
<td>Sales (million won)</td>
<td>31</td>
<td>1,346,010</td>
<td>4,979,481</td>
<td>4,030</td>
<td>2.75E+07</td>
</tr>
<tr>
<td>Net profit after tax (million won)</td>
<td>34</td>
<td>56577.85</td>
<td>307,721.5</td>
<td>-172,845</td>
<td>1,784,550</td>
</tr>
<tr>
<td>Three firm concentration ratio</td>
<td>38</td>
<td>0.460</td>
<td>0.180</td>
<td>0.236</td>
<td>0.746</td>
</tr>
<tr>
<td>Capital intensity(million won/employee)</td>
<td>36</td>
<td>172.333</td>
<td>281.647</td>
<td>0.840</td>
<td>1,411.415</td>
</tr>
</tbody>
</table>

**4. Estimation Results**

The result of the logit estimation to test the first hypothesis is reported in Table 3. Since variables used here are proxies and not direct measurements, interpretation focuses on the signs of the coefficients rather than on the size of the coefficients. When capital intensity (CAPIN) is used as the proxy for technology transfer cost, the sign of its coefficient is negative as predicted by theory. However, it is not statistically significant.

When the dummy variable showing whether the firm belonged to one of the high technology industries (HITECH) is used as the proxy for technology transfer cost, the...
The coefficient becomes positive, unlike the theoretical prediction. This may be because of the nature of technology transfer. Some technologies can be easily codified into explicit knowledge (e.g., patents, formulas, detailed manuals etc) whereas some technologies are implicitly embedded knowledge (e.g., informal knowledge, experience, know-how). Even in highly capital intensive, complex technology industries, explicit knowledge would be easier to transfer than implicit knowledge. The chemical industry (including pharmaceutical industries) is highly capital, technology intensive, and the innovation process arduous, but it is well known that knowledge in this industry can be easily codified into a formula, once a new substance is innovated. It can be better protected by patents than in most other industries, and the knowledge is thus easier and less costly to transfer.\(^7\) The same maybe true of the electric and electronics industry, which is technologically dynamic but software programs and circuit designs can be readily codified and are increasingly protected by copyrights.\(^8\)

On the other hand, in industries such as transportation equipment and machineries, codified knowledge such as patents do not play a big role in protecting or transferring technology, but informal exchange of information, experience, contractual relations between component suppliers and auto producers, and know-how play a greater role in disseminating technology. The HITECH2 variable is constructed to reflect this explicit-implicit dichotomy. It excludes chemicals, electric and electronics industries from HITECH. The third column of Table 3 reports estimation results using HITECH2 as the proxy for technology transfer cost. There is no significant change in the results. The coefficient is still positively signed and insignificant.

The competition variable CR3, which measures the level of concentration, is consistently positively correlated with occurrence of M&A as predicted by theory. However, this variable is also not statistically significant. That is, while the data broadly supports theory with respect to relationship between concentration and mode of entry decision, the relationship is not strong enough to be captured statistically.

Although the theory predicts that M&A is positively correlated with low technology transfer cost and low competition levels, it is possible that both of these conditions must

\(^7\) The explicit-implicit knowledge dichotomy is here loosely defined. For a critique of how these concepts are used in economics, see Cowan, David and Foray (2000).

\(^8\) It is possible that electronic industry also considerably relies on informal knowledge transfers between experts, and user feedbacks. Excluding only the chemicals industry, however, did not significantly change the results.
be present together to induce M&A. This calls for including an interaction term into the estimation. The interaction term is constructed by interacting two dummy variables: \( CR3HI \) which takes the value of 1 when \( CR3 \) is less than 0.3 (below 30\(^{th} \) percentile), and \( CAPIN\_Low \) which takes the value of 1 when capital intensity is less than 29 (below 30\(^{th} \) percentile). Since M&A is more likely to occur when technology transfer cost is low and when competition level is low, the coefficient for the interaction term should be positive.

The last three columns present the results from the same estimation but including an interaction term. In all cases, the interaction term is positive as expected, except when \( HITECH \) is used as a proxy for transfer cost. However, this variable is still not significant. Including the interaction term turns the coefficients for the competition variable to be negative, while the signs of coefficients for the technology transfer cost variables are retained.

Table 3: Effect of Technology Transfer Cost and Competition on Mode of Entry

<table>
<thead>
<tr>
<th>( Y = 1 ) if MA | ( = 0 ) if GF</th>
<th>Technology Transfer Cost</th>
<th>With the Interaction Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \tau ) | ( \tau ) | ( \tau ) | ( \tau ) | ( \tau ) | ( \tau ) |</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAPIN | HITECH | HITECH2 | CAPIN | HITECH | HITECH2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.0006 | 0.557 | 0.633 | -0.0004 | 0.653 | 0.627</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1.033) | (0.729) | (0.882) | (0.002) | (0.818) | (0.912)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CR3 | CR3 | CR3 | CR3 | CR3 | CR3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.462 | 1.539 | 0.344 | -0.627 | -0.158 | -1.728</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1.972) | (1.912) | (2.327) | (2.428) | (2.529) | (2.957)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction Term | Interaction Term | Interaction Term | Interaction Term | Interaction Term | Interaction Term</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(CR3HI$^<em>$CAPIN$_Low$) | (CR3HI$^</em>$CAPIN$_Low$) | (CR3HI$^<em>$CAPIN$_Low$) | (CR3HI$^</em>$CAPIN$_Low$) | (CR3HI$^<em>$CAPIN$_Low$) | (CR3HI$^</em>$CAPIN$_Low$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.921 | 0.634 | 1.042</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1.181) | (1.243) | (1.175)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant | Constant | Constant | Constant | Constant | Constant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.104 | -1.088 | -0.576 | 0.207 | -0.487 | 0.202</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.0016) | (1.133) | (0.933) | (1.108) | (1.358) | (1.086)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Figures in ( ) are robust standard errors.

Table 4 reports the estimation results from the OLS regression to test the second hypothesis regarding the effect of technology transfer cost and competition on strategic
incentive to transfer technology. As predicted by theory, strategic effect is negatively correlated with technology transfer cost, whichever proxy is used. At the same time, the strategic effect is positively correlated with competition, but is negatively correlated with the squared, quadratic term of competition as predicted by theory. That is, competition has an increasing effect on strategic incentives at a low level of competition, but a decreasing effect at a high level of competition. Nevertheless, again, none of the coefficients are statistically significant.

Table 4. Effect of Technology Transfer Cost and Competition on Strategic Effect

<table>
<thead>
<tr>
<th>Dependent Variable = Strategic Effect</th>
<th>Independent Variables</th>
<th>ΔQ/ΔX</th>
<th>Δπ/ΔX</th>
</tr>
</thead>
<tbody>
<tr>
<td>HITECH2</td>
<td>-824037.2</td>
<td>-65091.57</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(610795.3)</td>
<td>(63410.94)</td>
<td></td>
</tr>
<tr>
<td>COMP</td>
<td>9516.062</td>
<td>3155957.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(377891)</td>
<td>(324244.9)</td>
<td></td>
</tr>
<tr>
<td>COMP²</td>
<td>-9514.895</td>
<td>-53062.57</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(628295.4)</td>
<td>(54437.78)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>97285.78</td>
<td>-388317.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4751315)</td>
<td>(400425.6)</td>
<td></td>
</tr>
</tbody>
</table>

N = 33  R² = 0.0288  F(3, 29) = 0.65
N = 33  R² = 0.0716  F(3, 29) = 0.39

Note: The figures in ( ) are robust standard errors.

5. Conclusion

Overall, the estimation results generally support the hypotheses with respect to the relationship between mode of FDI entry, technology transfer cost and competition. M&A is generally more likely to occur when technology transfer cost is low and concentration level is high. Due to the underlying effect of competition on the strategic incentive to transfer technology, which increases with competition at low levels of competition but decreases at high levels of competition, M&A has lower incentive to transfer technology when it is most likely to occur.
A real life example is the contrasting technology transfer processes of two FDI cases, one entering as M&A and the other as greenfield. Celltrion entered the Korean market as a joint venture between Vax Gen, a California based biotechnology firm and three Korean investors in 2002. Green Cross Vaccine Corporation was established by the Korea Green Cross Corporation in 1999. In 2000, Rhein Biotechnology bought 80% of its equity in a strategic alliance. Then in 2002, it became a subsidiary of the Berna Biotechnology when Berna merged with Rhien. Both Celltrion and Green Cross Vaccine belong to the same industry (biopharmaceutical manufacturing: KSIC D24212). Since the pharmaceutical technology may be classified as explicit technology, and since Korean pharmaceutical manufacturing abilities are fairly advanced, technology transfer cost in this industry is not expected to be very high. At the same time, this industry is a concentrated industry, with CR3 being as high as 68% in 2000. So, this is a case where M&A is more likely to occur, but has less strategic incentive to transfer technology.

Celltrion, entering as a Greenfield joint venture, is the aberrant case, and should be transferring technology more aggressively than Green Cross Vaccine Corporation. This seems to be true, at least at the time of entry. In the case of Celltrion, manufacturing is based mainly on Vax Gen technology (AIDS vaccine) from the start, and plans for new future products are based on technology to be transferred from Vax Gen, although Celltrion itself will conduct biopharmaceutical research. In the case of Green Cross Vaccine Co., which already had a history of producing the Hepatitis-B vaccine and combined vaccines, was made to refocus on these core activities, rather than immediately launching into new products with new technology coming from the foreign investor.

If greater technology transfer is the goal of governments, theory suggests that governments could give incentives to induce the kind of entry mode that has the greater strategic incentive to transfer technology but is not likely to occur given the level of transfer cost and competition. That is, the rationale for government intervention is not because any one mode of entry is always worse for technology transfer, but because in both cases, under certain circumstances, the mode that is likely to occur does not transfer technology as much as the other mode of entry. For example, Celltrion benefitted from some government support when it located its facilities in the Incheon Free Economic Zone, under a situation when mode of entry would have more likely to have been M&A, with weaker incentives to transfer technology. It is interesting to note
that greenfield occurred through a joint venture, which is similar to mergers in that for both entry modes, the motivation is to benefit from synergies between the foreign investor and the domestic partner. In industries where technology transfer cost is high but the market is competitive, barriers against M&A could be lowered so as to induce M&A, which is less likely to occur but has greater incentives to transfer technology, and overall decrease in competition levels not so serious.

While the estimation results from this paper suggest that relationships between the variables of interest generally support theory, they also indicate the strength of the relationships is not statistically significant. That is, these relationships are not strong enough to warrant making a clear distinction between the effects of M&A and greenfield FDI and that governments should be cautious in introducing regulation discriminating between greenfield and M&A. Such policies may not be as effective as suggested by theory, given that the difference in economic impact of the different modes of entry may not be very strong.

The results of this paper can only be taken as preliminary. At the theoretical level, this paper ignored the possible difference in incentives to transfer technology depending on whether the investment is horizontal or vertical. In addition, a deeper exploration of what exactly constitutes technology transfer cost and how it should be measured is a task that remains. Main shortcomings of the analysis originate from the difficulties of acquiring appropriate data. The current data set does not have information on whether the FDI was vertical or horizontal, nor information on technological activities at the firm level. Another shortcoming in the data set is that the concentration measure has been averaged over industry aggregation that is very broad. Competition intensity should be measured at a much lower market level to be meaningful. Most of all, the analysis would benefit from an expanded data set.
References


Appendix: The Model

1. Product Market Competition

The model assumes a basic Cournot competition with the following profit function, where $\pi$ is profit, $p$ is price, $q$ is quantity, $c$ is cost, $a$ is a constant, and the subscript $i$ represents the $i^{th}$ firm, and $i$ all other firms:

$$\pi_i(q_i, q_{-i}) = (p(q) - c_i)q_i = (a - q_{-i} - q_i - c_i)q_i$$

The cost of the domestic firm is just $c$, while the cost of the foreign firm is $c-x$, so that its costs fall as it transfers more technology. There is cost to transfer technology, however, which increases with the amount of technology transferred $x$, and a cost parameter $\tau$ as follows:

$$C(x) = \tau \cdot \frac{x^2}{2}, \quad \tau = \frac{\partial^2 C}{\partial x^2}$$

Solving for quantities gives the output levels of the foreign and domestic firms under M&A and greenfield FDI, where $n$ is number of firms, $A$ denotes M&A, $E$ denotes greenfield, $f$ denotes foreign firm and $h$ denotes domestic firm:

$$q_f^A = \frac{a + (n-1)x - c}{n}, \quad q_h^A = \frac{a - c - x}{n}$$

$$q_f^E = \frac{a + nx - c}{n+1}, \quad q_h^E = \frac{a - c - x}{n+1}$$

Using the profit function and the quantities, the profits of foreign and domestic firms under each mode of FDI entry are shown to be:

$$\pi_f^E(x^E) = \frac{(a - c)^2 \tau}{2n(\tau - n) + \tau(n^2 + 1)}, \quad \pi_h^E(x^E) = \left[ \frac{(a - c)(m - 2n + \tau)}{2n(\tau - n) + \tau(n^2 + 1)} \right]^2$$
\[ \pi_f^A(x^A) = \frac{(a-c)^2}{2n(2-n)^4}, \quad \pi_h^A(x^A) = \left[ \frac{(a-c)(m+2-2n)^2}{2n(2-n)^4} \right]^2 \]

2. Technology Transfer

The first order condition for technology transfer under greenfield is written as follows:

\[ \frac{\partial \pi_f^E}{\partial q_f} \frac{\partial q_f}{\partial \xi} + (n-1) \frac{\partial \pi_f^E}{\partial q_h} \frac{\partial q_h}{\partial \xi} + \frac{\partial \pi_f^E}{\partial x} - \frac{\partial C(x)}{\partial \xi} = 0 \]

The second term represents the strategic effect: the change in profit of the foreign firm due to the change in output of the domestic firm, which in turn is a response to the technology transfer by the foreign firm. Using the profit function to obtain the derivatives of the profits, the strategic effect can be rewritten as follows for greenfield entry and M&A entry respectively:

\[ S^E = (n-1)(q_f^E)\frac{\partial q_h^E}{\partial \xi} + q_f^E - \alpha = 0 \]

\[ S^A = \frac{n-2}{n} q_f^A + q_f^A - \alpha = 0 \]

Replacing the quantities from above, the strategic effect can be expressed in terms of number of firms and technology transfer cost. It is shown to be concave in \( n \), while decreasing in \( \tau \):

\[ \frac{\partial S(n, \tau)}{\partial \tau} = \frac{-2(n-1)(a-c)n^2}{(-2n^2 + m^2 + 2m + \tau)^3} \]

\[ \frac{\partial S(n, \tau)}{\partial n} = \frac{(a-c)(-2n^2 + m^2 - 2m - 3\tau + 4n)\tau}{(-2n^2 + m^2 + 2m + \tau)^3} \]

From this, the critical number of firms beyond which the strategic effect begins to decline with respect to number of firms, \( n^c \), is given by:

\[ n^c(\tau) = \frac{\tau - 2 + \sqrt{2} \sqrt{(\tau - 2)(2\tau - 1)}}{\tau - 2} \]
Solving the equations for strategic incentives yields \( x \), the extent of technology transfer under the two modes of entry respectively:

\[
x^e = \frac{2n(a - c)}{(\tau - 2)n^2 + (2n + 1)\tau}
\]

\[
x^A = \frac{2(n-1)(a-c)}{(4n-2)+(\tau-2)n^2}
\]

The foreign firm transfers equal amount of technology when the critical transfer cost parameter \( \tau \) is \( \tau_r(n) = \frac{2n(n-1)}{n^2 - n - 1} \). That is, technology transferred is less under acquisition if \( \tau < \tau_r(n) \).

3. Entry Mode Decision.

The foreign firm chooses to enter through M&A if profit under M&A is greater than under greenfield as follows, where \( \pi_f^A(x^A) \) is the buyout price the acquiring firm has to pay:

\[
\Delta \Pi = \pi_f^A(x^A) - C(x^A) - \pi_h^A(x^A) - \pi_f^A(x^E) - [\pi_f^E(x^E) - C(x^E)] > 0
\]