GREENFIELD INVESTMENT OR ACQUISITION? OPTIMAL FOREIGN ENTRY MODE WITH KNOWLEDGE SPILOVERS IN A COURNOT GAME

By

LEO GRÜNFELD
NUPI-Norwegian Institute of International Affairs
P.O. Box 8159, Dep. N0033, Oslo, Norway
E-mail: leoa.grunfeld@nupi.no
Tel: 47-22-056568
Fax: 47-22-177015

and

FRANCESCA SANNA-RANDACCIO
University of Rome “La Sapienza”
Via Buonarroti 12
00185 Rome, Italy
E-mail: fsr@dis.uniroma1.it
Tel: 39-06-48299228
Fax: 39-06-48299218

15 July 2005

Abstract:

The theoretical literature on FDI and knowledge spillovers has predominantly focused on the firms’ choice between greenfield investment and exports. This is somewhat surprising since almost 80% of all FDI relates to M&As. The few studies that investigate the choice between greenfield investment and M&A with knowledge spillovers almost exclusively focus on North-South issues where knowledge only runs one way and firms from the developed countries are the only ones that expand abroad. However, since most M&As are conducted in a North-North setting, we find good reasons to develop a model that allows foreign entry running both ways.

In this paper, we identify the optimal foreign entry mode in a two country, two firm Cournot model with asymmetric technology levels and country sizes. If a firm enters the foreign market through greenfield investment, it has to pay a fixed investment cost and its technology level is reduced in the foreign market due to knowledge transfer costs. If a firm enters through acquisition, it must offer the other firm a sufficiently high acquisition price in order to get an acceptance. If the bid is accepted through a bargaining process, the acquirer becomes a monopolist in both markets using the best technological practice adjusted for transfer costs. Our model does not include exports as a strategic option, thus the model is best suited for studies of firms operating in service sectors or sectors where there are high fixed export costs.

JEL classifications: L13, F23, O31, O38
Keywords: Multinational firms, mergers and acquisitions, R&D investment

Presented at the
ETSG Seventh Annual Conference
University College Dublin
8-10 September 2005

1 Financial support by the Norwegian Research Council is gratefully acknowledged by the two authors
1. Introduction

In recent years, the internationalisation of firms has assumed two new features. First, firms increasingly enter foreign markets by acquiring a local producer (acquisition) instead of opening a new subsidiary (greenfield investment). The phenomenon is particularly pronounced in industrialized host countries, where the bulk of foreign direct investment (FDI) inflows enters through acquisition. For instance in 1998 acquisitions accounted for 90% of inward FDI in the US\(^2\) (UNCTAD, 2000, p.118). Most of these investments are directed towards the service sector and not to manufacturing, as in the past. During 2001-2002 services accounted for two-thirds of total FDI inflows. In fact, while in the early 1970s services accounted for only one quarter of the world FDI stock, by 2002 this share had risen to about 60% (UNCTAD, 2004, p. xx).

Second, the interaction between the international strategy and the innovative activity of firms has become increasingly tight and complex, due to the key role of multinational companies (MNEs) in the process of generation and transfer of technology and knowledge in the global market. Models therefore should be framed to account for the features which nowadays characterise the internationalisation process, capturing the technological implications of cross-border acquisitions.

The formal literature however has largely ignored these important trends. Most of the theoretical literature is still devoted to explain the drivers and effect of greenfield FDI in the manufacturing sector (Horstmann and Markusen, 1992; Barba Navaretti and Venables, 2004; Petit and Sanna-Randaccio, 2000; Grunfeld 2003). Such models cannot help analyzing these recent trends for several reasons. To start with, as opposed to manufactured products, most services are not tradable, thus the traditional way in which these models are framed (the choice between export and FDI) cannot be applied to the service context. Second, while greenfield FDI is considered, foreign entry via acquisition is not accounted for. As a consequence, the results of these models as to welfare implications and policy prescriptions can be applied only to special cases, while the determinants and implications of what is now the bulk of FDI activity remain unexplored.\(^3\)

---

\(^2\) The figure refers to M&A however the same source indicates that acquisition dominates the scene, since less than 3% of cross-border acquisitions by number are mergers (UNCTAD, 2000, p. 99).

\(^3\) There is an interesting managerial literature of a more descriptive type which has suggested some interesting hypothesis which however have not yet be examined in a more formal context.
In this paper, we identify the optimal foreign entry mode in a two country, two firm Cournot model with asymmetric firm technology levels and asymmetric market (country) sizes. We are particularly concerned with such asymmetries because the size of a market may affect the decision on how to enter this market. And moreover, the relative technological level of a firm also contributes to determine the profitability of entering foreign markets. We specifically ask in which setting a technologically inferior firm from a large country finds it optimal to buy a technology leader from a small country or vice-versa. Answering this question is important since many politicians and business sector representatives in smaller industrialized countries express serious concerns as to the fact that multinationals from large countries tend frequently to acquire firms that have their home base in small countries. As opposed to the majority of earlier theoretical models on international mergers and acquisitions, we explicitly allow for FDI running both ways between countries. This is a desirable property in the case of investments running between industrialised countries, where multinationals often compete in each other’s home markets.

In the first stage of our model, firms simultaneously choose between no entry, greenfield investments or acquisition of a local. In the second stage they set the profit maximizing level of output. If a firm enters the foreign market through greenfield investment, it has to pay a fixed investment cost and its technology level is reduced in the foreign market due to technology transfer costs. If a firm enters through acquisition, it must offer the other firm a sufficiently high acquisition price in order to get an acceptance. If the bid is accepted through a bargaining process, the acquirer becomes a monopolist in both markets and will gain from two effects. First, the merged firm will use the best technological practice in each location adjusted for technology transfer costs. Second, we allow for synergy effects that improve productivity. Our model does not include exports as a strategic option, thus the model is best suited for studies of service sectors or sectors where there are high fixed export costs. As mentioned above, these sectors account for a dominating proportion of all FDI between industrialized countries, whether it is greenfield or M&A.

In the model we try to capture the main stylized facts that emerge in the empirical literature. We consider competition between two innovative firms based in developed countries. The model addresses the case of full acquisitions, which are horizontal and friendly.\(^4\) We account for the knowledge flows associated with the acquisition, allowing for the best practice

\(^4\) UNCTAD-DTCI, 2000, shows that full acquisitions accounted for more than half of all cross-border M&A in 1999; in the same year 70\% of the value of cross-border M&A were horizontal. In addition the overwhelming number of both domestic and international acquisitions are friendly rather than hostile take-overs.
effect and the synergy effect. Furthermore costs associated with the acquisition due to legal fees, consulting fees and costs of integrating the two company cultures are also included in the model.

We find that the equilibrium acquisition price reflects the target firm potential for growth, in other words it depends on what the target firm would do in the case of no acquisition. In addition, the model shows that the acquirer is always the firm that would have the highest profit if the acquisition fails.

If the technology leader comes from a large country, it will – except for some extreme configurations - be the acquirer if there is any cross border take over at all. If the technology leader comes from a small country, the picture is slightly more complicated. With high barriers to multinational expansion (so that both firms prefer no entry to greenfield investment), and if the market size difference is large, the firm will be acquired by the technology follower from the large country. But if the equilibrium alternative to the acquisition is one-way or two-way greenfield investments and the cost of technology transfer within the MNE is low, the firm will acquire the technology follower from the large country.

It is important to notice that our model predicts that as greenfield investment becomes less costly, the likelihood of observing an acquisition as the equilibrium outcome increases. In other words, if the globalisation process leads to e.g. lower fixed investment costs under greenfield, it does not necessarily mean that we will see more greenfield investment, but rather more acquisitions. This prediction seems to fit the described development mentioned above.

The paper is organised as follows. In section 2, we briefly survey the relevant literature on this subject and clarify what distinguishes our model from previous studies. Section 3 presents the model. Section 4 analyzes the non-cooperative constrained game with a strategy space including no entry and greenfield FDI. Section 5 analyses the acquisition decision in a cooperative game framework, by applying the Nash fixed threat bargaining model. In Section 6, considering different scenarios, we illustrate with the use of numerical analysis which firm will be the acquirer in a cross-border deal. Finally, Section 7 presents the main conclusions.

2. Earlier theoretical contributions

A few recent theoretical papers have addressed the issue of FDI via cross-border acquisition. Mattoo, Olarreaga and Saggi (2004) present a model in which a foreign firm decides first on the mode of entry (greenfield FDI or acquisition), then the extent of technology transfer to the subsidiary. The third stage of the game is the output game in which the foreign firm compete à la Cournot in the host country with n-1 local firms. FDI policy is set prior to the first stage game by the host country government. They focus on the relationship between mode of
entry, technology transfer and market structure. The analysis highlights how the foreign firm’s equilibrium choice and the local government ranking of the two modes of entry is affected by the cost of technology transfer within the MNE. The model thus is framed to be applied only to a North South context, since only one firm can expand abroad, the knowledge flow is one way and the repercussions on the home market activities of the investor are not considered.

Horn and Persson (2001) focus on acquisitions in developed countries. They consider in a symmetric model of four firms (two in each country) which choose whether to export abroad or to acquire a foreign firm. The focus is on trade costs and their influence on the incentive to form either domestic or international mergers. The case of full acquisition is analyzed, considering merger formation as a cooperative game of coalition formation. The model does not yield precise prediction on the division of payoffs in a merger, which makes it impossible to conduct a complete welfare analysis. Furthermore only the choice between export and FDI through acquisition is allowed for, excluding the possibility of greenfield FDI.

Ferret (2003) considers an international oligopoly with two firms and two symmetric countries. Each firm decides on its foreign expansion mode (acquisition, greenfield and export) and whether to innovate. A third firm also decides whether to enter the market. He finds that necessary conditions for greenfield FDI are a large market and a small sunk cost of additional plant while acquisition FDI arises in medium sized markets. Firms compete in the last stage (the output game) à la Bertrand and the reason for this specification is not explained. The acquisition price (the bid) is not determined and thus it is not clear which firm will be the acquirer. The different costs and benefits associated with an acquisition are not fully analyzed and the importance of knowledge flows in the integrated company is not accounted for.

3. The model

We present a model with two countries (countries I and II) and two firms, firm 1 and 2, that manufacture the same homogeneous good in countries I and II respectively. As we will see below, countries may vary in size and firms may differ as to cost reducing exogenous technology.

The problem is structured as a two stage game. In the first stage firms decide the mode of foreign expansion choosing amongst three possible strategies: no expansion abroad – N -. 


greenfield FDI – G - and full acquisition⁵ of the foreign firm – A -. In the second stage firms maximize profits by choosing optimal output either as a monopolist or as a Cournot competitor.

Both firms introduce cost saving innovations. We assume that a total knowledge pool is divided between the two firms in proportion \( \sigma \) for firm 1 and \( 1-\sigma \) for firm 2 with \( \sigma \in [0,1] \). We then obtain that unit variable production costs depend on the firm’ exogenous cost reducing technology.

The unit variable cost in the home market respectively for firm 1 and firm 2, both when the firm does not expand abroad or expand abroad via greenfield investment, are given by

\[
c_{1,I} = c_0 - \sigma \\
c_{2,II} = c_0 - (1-\sigma)
\]

The parameter \( c_0 \geq 1 \) can be considered as the initial constant marginal cost of production of firm \( i \), thus the cost that would prevail with no process innovation. We assume that there is no involuntary dissemination of knowledge (thus no external spillovers) when the two firms are under separate ownership. Consequently in the case of greenfield FDI⁶ there is no reverse knowledge transfer from subsidiary to parent.

The unit variable cost of production abroad when the firm makes a greenfield investment indicates that the cross border internal know how transfer from parent to subsidiary is costly. The costs of internal know how transfer are inversely related to the parameter \( \tau \in [0,1] \). We have

\[
c_{2,f} = c_0 - \tau(1-\sigma) \\
c_{1,II} = c_0 - \tau\sigma
\]

Therefore with multinational production – due to costs of internal knowledge transfer - the subsidiary is less efficient than its parent.

A cross border acquisition has important technological implications which influence the firm’s cost of production. More specifically if firm 1 makes the acquisition, its unit production cost in country I and II respectively are:

\[
c_{1,I} = c_0 - \left[ \max \{\sigma, \tau(1-\sigma)\} + \rho(\sigma(1-\sigma)) \right] \\
c_{1,II} = c_0 - \left[ \max \{\tau\sigma, (1-\sigma)\} + \rho(\sigma(1-\sigma)) \right]
\]

⁵ Here we do not allow firms to involve in a merger where the parties own a percentage share of the firm. Such a possibility will complicate the model since we both will have to specify merger price and a sharing rate of profits between parties. Mattoo et al (2004) also show that the equilibrium M&A always is a 100% acquisition.

⁶ This is an extreme assumption made for sake of tractability of the model which however allow us to capture that the transfer of know how between firms is more intense if there is an acquisition than in the case of arm’s length relationships.
while if firm 2 makes the acquisition we have:

\[ c_{2,II} = c_0 - \left[ \max \{ (1-\sigma), \tau \sigma + \rho(\sigma(1-\sigma)) \} \right] \]  
(7)

\[ c_{2,j} = c_0 - \left[ \max \{ \sigma, \tau(1-\sigma) + \rho(\sigma(1-\sigma)) \} \right] \]  
(8)

We allow for two main effects. On the one hand we have a best practise effect (the first term in the square brackets in Eqs (5)-(8)). That is to say, we assume that the new company adopts in each market what is the most efficient technology between that available in house and that available in the target company in that particular market. So if firm 1 is the acquirer and the target firm (firm 2) is an MNE, in country I firm 1 will have the possibility to adopt either its own technology (\( \sigma \)) or that of the subsidiary of firm 2, that is \( \tau(1-\sigma) \). We also consider a synergy effect captured by the second term in square brackets in Eqs (5)-(8). Due to the complementarity between the technology developed by the acquirer and by the target firm, the acquisition results in a lower unit production cost. The synergy effect is at its maximum when the technology levels of the two firms are relative similar. The parameter \( \rho \) (with \( \rho \geq 0 \)) captures the intensity of this effect.

In addition, if a firm chooses to enter a foreign market through greenfield investment it faces a fixed cost \( F \) as a new production unit should be built. Furthermore, with an acquisition there are also additional costs of both organisational and financial nature which will be discussed in section 4.

On the demand side, we consider linear (inverse) demand functions, that is:

\[ p_J(q_{1,J} + q_{2,J}) = a(s - Q_J) \]  
(9)

\[ p_{II}(q_{1,II} + q_{2,II}) = a(1-s) - Q_{II} \]  
(10)

where \( Q_J = q_{1,J} + q_{2,J} \) for \( J=I,II \) and the parameter \( a \) measures the size of the world market while the parameter \( s \in (0,1) \) indicates the share of the world market accounted for by country I and thus \((1-s)\) the share accounted for by country II.

The profits of the two firms differ depending on the market configurations. Six possible market configurations may arise: (N,N) each firm produce and sell only in the home market; (G,N) firm 1 undertakes a greenfield FDI while firm 2 operates only in the domestic market; (NG) firm 2 opens a new plant abroad and firm 1 operates only at home; (GG) we a have a MNE duopoly as both firms undertake greenfield FDI; (A1) firm 1 acquires firm 2; (A2) firm 2 acquires firm 1. The payoff functions for each of these market structures are reported in Appendix 1.
The optimal foreign entry mode is found by solving a two stage game. In the first stage firms choose the mode of entry, while in the second they decide the profit maximizing level of output. As usual, the game is solved backwards. Cournot-Nash equilibrium for sales is thus computed first, with the levels of optimal sales computed for each market configuration. The first stage is then solved, with firms choosing among \( N, G, A \). We first find the non-cooperative solution of the constrained game with strategy space \( S_i = \{N, G\} \). Then we solve the acquisition decision by applying the Nash fixed-threat bargaining equilibrium concept.

4. The equilibrium mode of entry: the non-cooperative game with \( S_i = \{N, G\} \)

We shall now discuss how the firms will make their choices regarding the mode of foreign expansion. Before addressing the acquisition decision we should determine the solution of the constrained non-cooperative game with strategy space \( S_i = \{N, G\} \) with \( i = 1, 2 \). In this way we determine what will be the equilibrium mode of entry if the acquisition does not take place. In order to analyze the choice between no entry and greenfield investment we need to know the profits of each firm corresponding to the different possible market configurations. Then we have to obtain the Nash equilibrium solution \( (S_{ij}^*) \) of a matrix game between the two firms where the pay-offs are the equilibrium profits of each single firm (see Table 1).

The equilibrium profits for each market configurations, obtained by substituting in Eq.s A1-A10 the optimal sales we get by solving the second stage games, are:

\[
\hat{\pi}^{NN}_1 = \frac{(sa - c_o + \sigma)^2}{4}
\]

\[
\hat{\pi}^{NN}_2 = \frac{((1-s)a - c_o + (1-\sigma))^2}{4}
\]

\[
\hat{\pi}^{NG}_1 = \frac{(sa - c_o + 2\sigma - \tau(1-\sigma))^2}{9}
\]

\[
\hat{\pi}^{NG}_2 = \frac{((1-s)a - c_o + (1-\sigma))^2 + (sa - c_o + 2\tau(1-\sigma) - \sigma)^2}{9} - F
\]

\[
\hat{\pi}^{GN}_1 = \frac{(sa - c_o + \sigma)^2}{4} + \frac{((1-s)a - c_o + 2\tau(1-\sigma) - \sigma)^2}{9} - F
\]

\[
\hat{\pi}^{GN}_2 = \frac{((1-s)a - c_o + 2(1-\sigma) - \tau\sigma)^2}{9}
\]

\[
\hat{\pi}^{GG}_1 = \frac{(sa - c_o + 2\sigma - \tau(1-\sigma))^2}{9} + \frac{((1-s)a - c_o + 2\tau(1-\sigma))^2}{9} - F
\]
\[ \hat{\pi}_{2}^{GG} = \frac{(sa - c_0 + 2\tau(1 - \sigma) - \sigma)^2}{9} + \frac{((1 - s)a - c_0 + 2(1 - \sigma) - \tau\sigma)^2}{9} - F \]  

(18)

By comparing the profit functions under alternative strategy combinations, we can identify the conditions for dominant strategies:

\[ \frac{[(1 - s)a - c_0 + 2\tau\sigma - (1 - \sigma)]^2}{9} > F \]  

(19)

\[ \frac{[sa - c_0 + 2\tau(1 - \sigma) - \sigma]^2}{9} > F \]  

(20)

If Eq. 19 holds, \( G \) is the dominant strategy for firm 1. Otherwise, \( N \) will be the dominant strategy.\(^7\) Similarly, if Eq. 20 holds, \( G \) will be the dominant strategy for firm 2.\(^8\)

As to the effect of relative market size (captured by the parameter \( s \)), the probability that Eq. (19) (Eq. (20)) holds and thus that firm 1 (firm 2) establishes a new subsidiary abroad is decreasing (increasing) in \( s \):

\[ \frac{\partial \text{LHS}(19)}{\partial s} = -a \frac{2[(1 - s)a - c_0 + 2\tau\sigma - (1 - \sigma)]}{9} < 0 \]  

(21)

\[ \frac{\partial \text{LHS}(20)}{\partial s} = a \frac{2[sa - c_0 + 2\tau(1 - \sigma) - \sigma]}{9} > 0 \]  

(22)

This finding reminds us that a large host market (ceteris paribus) is an important attractor for inward FDI since it will imply higher variable profits, making it more easy to compensate for the additional fixed plant costs associated to a greenfield investment (F). Both these effects are more powerful the larger the size of the overall market (that is the higher the parameter \( a \)).

As to technological asymmetry (captured by the parameter \( \sigma \)), the probability that Eq. (19) (Eq. (20)) holds and thus that firm 1 (firm 2) establishes a new subsidiary abroad is increasing (decreasing) in \( \sigma \):

\[ \frac{\partial \text{LHS}(19)}{\partial \sigma} = (2\tau + 1) \frac{2[(1 - s)a - c_0 + 2\tau\sigma - (1 - \sigma)]}{9} > 0 \]  

(23)

\[ \frac{\partial \text{LHS}(20)}{\partial \sigma} = -(2\tau + 1) \frac{2[sa - c_0 + 2\tau(1 - \sigma) - \sigma]}{9} < 0 \]  

(24)

This suggests that the technologically leading firm is more likely to expand abroad than the weaker competitor. Its unit variable cost advantage implies that by producing abroad it will

\[^7\] If Eq.(19) holds we have that: \( \hat{\pi}_1^{GG} > \hat{\pi}_1^{NG} \) and \( \hat{\pi}_1^{GN} > \hat{\pi}_1^{NN} \)

\[^8\] If Eq.(20) holds we have that: \( \hat{\pi}_2^{NG} > \hat{\pi}_2^{NN} \) and \( \hat{\pi}_2^{GG} > \hat{\pi}_2^{GN} \)
enjoy –ceteris paribus- higher variable profits than its competitor. The advantage of the leading firm is greater the lower the cost of cross border internal technology transfer (the higher $\tau$ is) since low internal technology transfer costs imply that the leading firm will benefit more in the foreign market from its technological leadership.

The equilibrium strategy configuration clearly depends on the value of the parameters. Fig 1a and 1b illustrates how the Nash equilibrium strategy choice depends on the value of $s$ and $\sigma$, where the fixed investment cost ($F$) is set to 1.5 and 0.5 in Fig 1a and 1b respectively.

Insert Figure 1a and 1b here

The thick line in figures 1a and 1b represents the condition in Eq.(19) with strict equality, whereas the thin line represents the condition in Eq.(20). In the case where firm 1 has a technology advantage and its foreign market is relatively large (south-east in the diagrams), it will chose $G$, while firm 2 will chose $N$. By symmetry, the opposite strategies are chosen in the north-west corner of the diagrams. When $F$ is reduced, these two indifference lines shift upwards and downwards respectively, and when they shift positions, the equilibrium shifts from NN in Figure 1a to GG in Figure 1b. Since the two indifference lines are always parallel, no parameter combination allows both GG and NN to be equilibrium within the feasible $(s,\sigma)$ space.

If we increase $\tau$, which implies a smaller knowledge transfer cost, the indifference lines become steeper as illustrated in Figure 2. Hence, an increase in $\tau$ (smaller knowledge transfer costs) contributes to a larger area where GG is the equilibrium strategy choice and a smaller area where NN is the equilibrium.

---

9 Note that we are not considering external technological spillovers so we are ruling out greenfield FDI meant to technology sourcing.

10 In these figures, $a=3$, $\tau=0.5$ and $c_0 = 1$.

11 Eq.(19) can be rearranged as: $s < \frac{a - c_0 - x - 3\sqrt{F}}{a} + \frac{(2\tau + 1)}{a} \sigma$

12 Eq.(20) can be rearranged as: $s > \frac{c_0 - 2\tau + 3\sqrt{F}}{a} + \frac{(2\tau + 1)}{a} \sigma$
5. The equilibrium mode of entry with acquisition: the Nash fixed-threat bargaining solution

Let us first analyse what will be the equilibrium acquisition price when firm $i$ wants to acquire firm $j$. We can solve the problem as a cooperative game\(^{13}\), by using the Nash fixed–threat bargaining model (see Petit, 1990; Friedman 1990; Luce and Raiffa, 1957). The players bargain on how to divide the profits which are associated with the acquisition (see figure 3). The solution will allow us to obtain the equilibrium offer, thus the bid, which, in the case that firm $i$ wants to acquire firm $j$, is labelled as $B_i$.

The disagreement outcomes or *status quo profits* (point $d$ in figure 3) are given by the payoffs the players obtain if they fail to make an agreement. Point $d$ is the solution of the non-cooperative game with $S_i = \{N_i, G\}$ for $i=1,2$. Let us call these disagreement payoffs as $\pi^d_i$, and thus $d = (\pi^d_1, \pi^d_2)$.

The profits of the acquirer (firm $i$) are given by (see A9): \[
\Pi_i^{Ai} = (V_i^{Ai} - T_i) - B_i
\] (25)
\[
\text{where } V_i^{Ai} \text{ indicates the variable profits of the global monopolist, gross of acquisition costs } (T_i) \text{ and of acquisition price } (B_i). \text{ From Eq. (A11) and (A12) we see that } V_i^{Ai} = V_j^{Aj} = V_A \text{ given that each firm faces exactly the same markets and technology as global monopolist. Due to the best practise effect, the unit production cost in each market does not depend on which firm makes the acquisition. } T_i \text{ captures the costs associated to the acquisition (acquisition costs), due to legal fees, consulting fees, other intermediation costs which depend on the size of the deal. Furthermore the managerial resources to be devoted to the acquisition also depend on the size of the deal. } T_i \text{ captures also costs due to the efforts necessary to integrate the two work force. We can thus model these costs as increasing in the status quo size of the target firm, obtaining (with } \gamma > 0):}
\[
T_i = \gamma \pi^d_j
\] (26)

On the other hand, the profits for the target firm are given by the acquisition price:
\[
\Pi_j^{Ai} = B_j
\] (27)

The equilibrium bid, when firm $i$ makes an offer, is given by the Nash bargaining solution of the cooperative game. This is point $N$ on the negotiation set (segment AD in figure 3), such that the products of the gains obtained from the agreement (with reference to the threat

\(^{13}\)This way of dealing with the problem is in line with the empirical finding that the overwhelming number of M&A both domestic and international are friendly rather than hostile takeover.
point \( d \) is maximised. The Nash solution \( N \) can also be interpreted as the point on the AD segment which yields the largest rectangle for \( d \). Since the triangle AdD is equilateral and symmetric, \( N \) has coordinates \((\pi_i^d + \frac{1}{2} dD; \pi_j^d + \frac{1}{2} dD)\) 14 where \( dD = \{V^A - \gamma \pi_j^d\} - (\pi_i^d + \pi_j^d)\) represents the overall gain from cooperation, that is the excess profits from the acquisition when firm \( i \) is the acquirer. In other words the overall gain from cooperation is **evenly divided** between the two players.

The Nash solution thus gives us the equilibrium bid (i.e. the profits of the acquired firm \( j \)):

\[
B_j = \Pi_j^{Ai} = \pi_j^d + \frac{1}{2}\{V^A - \gamma \pi_j^d\} - (\pi_i^d + \pi_j^d) \tag{28}
\]

where the second term on the RHS in curly brackets indicates the excess profit from the acquisition, which is given by the difference between the profit of the global monopolist (net of acquisition costs) and the sum of the profits obtained by the two firms in the case of no acquisition. The acquisition price paid for the target firm thus reflect its potential for growth. It depends in fact on what firm \( j \) could have become if the acquisition did not take place, thus on the status quo profits and not on its existing profits (that in NN).

As to the acquirer, firm \( i \) will earn the following profit:

\[
\Pi_i^{Ai} = \pi_i^d + \frac{1}{2}\{V^A - \gamma \pi_j^d\} - (\pi_i^d + \pi_j^d) \tag{29}
\]

which represents the status quo profit plus the bargaining share of firm \( i \). These equations can be shortened as:

\[
\Pi_i^{Ai} = \frac{1}{2}\{V^A - \gamma \pi_j^d\} - \pi_j^d + \pi_i^d \tag{30}
\]

\[
\Pi_j^{Ai} = \frac{1}{2}\{V^A - \gamma \pi_j^d\} + \pi_j^d - \pi_i^d \tag{31}
\]

Thus the profits from acquisition for each firm are increasing in the global monopolist profits net of acquisition costs and in own status quo size, while they are decreasing in the rival’s status quo size.

An acquisition equilibrium requires that:

\[
\Pi_i^{Ai} > \pi_i^d \tag{32}
\]

and

\[
\Pi_j^{Ai} > \pi_j^d \tag{33}
\]

---

14 Note that \( dD = dA \).
Conditions (32) and (33) are satisfied iff:

\[ V^d > (1 + \gamma)\pi_j^d + \pi_i^d \quad (34) \]

Thus, if there are excess profits from the acquisition made by firm \( i \) (as compared to the status quo), the acquisition will take place since both firms will benefit from it.\(^{15}\) In other words Eq. (34) represents the necessary and sufficient condition for Eq. (32) and (33) to hold. Notice that in our model \( V^d \) is always larger than \( \pi_i^d \), since the firm is a monopolist in both markets with a superior technology. Actually, \( V^d \) is always larger than \( (\pi_i^d + \pi_j^d) \) since a global monopoly generates more revenue than the sum of all profits in the two separate duopolies. This also applies to the case where \((N,N)\) is the equilibrium in the status quo game, since the global monopolist can take advantage of the best practice and synergy effects. Thus, if there are no acquisition costs, an acquisition will always be the equilibrium. Basically, \( \gamma > 0 \) is required to have other equilibrium outcomes than acquisition in this game.

But which of the two firms will make the acquisition? Let us thus consider the case in which each firm can bid for the other. Firm \( i \) would like to be the acquirer if its profit is higher than the profit it receives from being acquired, that is iff:

\[ \Pi_{Ai}^i > \Pi_{Aj}^j \quad (35) \]

that is iff:

\[ \frac{1}{2}[(V^d - \gamma \pi_j^d) - \pi_j^d + \pi_i^d] > \frac{1}{2}[(V^d - \gamma \pi_i^d) - \pi_j^d + \pi_i^d] \quad (36) \]

which can be simplified as:

\[ \pi_i^d > \pi_j^d \quad (37) \]

The same condition is necessary and sufficient to have \( \Pi_{Aj}^j > \Pi_{Ai}^i \), so \( S_i^* = Ai \) iff conditions (34) and (37) are satisfied. This implies that firms’ technological level and relative home market size have an indirect impact on this decision, as they influence the solution of the non-cooperative status quo game with \( S_i = \{N,G\} \) for \( i=1,2 \). Thus we obtain:

\[ \boxed{\text{Result 1}} \]

*It is always the firm with the largest alternative (i.e status quo) profit that becomes the acquirer regardless of the size of \( \gamma > 0 \).*

\(^{15}\) This is the traditional criterion for merger incentive in the IO literature See Horn and Persson (2001).
6. Equilibrium solutions to the full game under alternative parameter configurations

We have found that the acquirer will be the firm with the largest size (as measured by profit) in the status quo equilibrium. That helps us to defines which firm is likely to be the acquirer and which the target in different scenarios. In Figure 4, we illustrate the different combination of firm characteristics in the \((s,\sigma)\) space. In the upper half, country I is the largest, while it is the smallest in the lower half. We only report for \(s\) between 0.5 and 1, since this region is sufficient to represent all possible combinations of the two firms.

**Insert figure 4 here**

In order to keep the analysis of the full game as tractable as possible we start out with the simplest case where both firms and countries are similar (no asymmetries), and then add asymmetries as we go along.

**Market size symmetry and technological symmetry \((s=0.5, \sigma=0.5)\)**

In the symmetric case \((s=0.5, \sigma=0.5)\) \(LHS\ Eq. (19) = LHS\ Eq. (20)\) and thus the equilibrium outcome will be either GG or NN. Which firm is the acquirer and which is the target is undetermined since both firms are indifferent as to who will be the acquirer, as \(\pi^d_i = \pi^d_j\). In addition there are no gains due to the best practice effect since when \(\sigma = 0.5\), the best practice technology under acquisition will always be \(\sigma = 0.5\).

Hence if there are no synergy effects, i.e. \(\rho = 0\), as the merged firm is a monopolist in both countries, we have that:

\[
V^A = 2\pi_i^{NN}
\]  

(38)

Overall profits from the acquisition is then given by:

\[
\Pi_i^{AI} = \frac{1}{2}[(V^A - (1 + \gamma)\pi_j^{NN}) + \pi_i^{NN}] = (1 - 0.5\gamma)\pi_i^{NN}
\]  

(39)

It follows directly from Eq. (39) that in the completely symmetric case, profits from the acquisition will always be lower than profits from the status-quo NN equilibrium, unless \(\rho > 0\) and the synergy effect outweighs the negative acquisition costs effect. However, this does not have to be the case if the status quo equilibrium is GG due to technology transfer costs and to \(F\) (plant fixed cost). This status quo equilibrium may materialize even though both firms get a higher profit from NN. In other words, this will be the case if we face a prisoner’s dilemma situation.
In figure 5, we have depicted the combinations of $\tau$ and $F$, for which GG or NN is a status quo equilibrium in the symmetric case.

Insert Figure 5 here

Clarely, if $\tau$ is large and $F$ is small, GG will be preferred to NN, and the larger $a$ is, the larger is the range of $(\tau, F)$ combinations where GG is the equilibrium, since a larger overall market size reduces the share of fixed costs ($F$) for each unit produced abroad. Thus, the indifference line shifts towards southeast as $a$ increases. Now, from Eq. (39) we know that an acquisition will be the equilibrium strategy choice if:

$$\Pi_i^{Al} = (1 - 0.5\gamma)\pi_i^{NN} > \pi_i^{GG}$$

which implies that

$$\gamma < \frac{2(\pi_i^{NN} - \pi_i^{GG})}{\pi_i^{NN}}$$

So even without synergy effects ($\rho = 0$), if the status quo is GG it is fully possible that an acquisition is the preferred strategy. If we include synergy effects, this requirement is further relaxed.

However, as mentioned above, under full symmetry, it is impossible to identify who will buy whom. An infinitesimally small deviation from the symmetry will however give rise to a fully identified acquisition equilibrium since one firm will have a slightly higher status quo profit than the other.

### Result 2

In the case with full symmetry, an acquisition will never be an equilibrium if NN is the equilibrium in the status quo game and the synergy effect is small relative to the acquisition cost effect. However, if GG is the status quo game equilibrium, an acquisition may be more profitable even without synergy effects.

**Market size asymmetry with technological symmetry ($s > 0.5, \sigma = 0.5$)**

If ($s > 0.5, \sigma = 0.5$) the incentive to invest abroad is greater for the firm based in the small country ($LHS$ Eq.(19) < $LHS$ Eq.(20)). The possible outcomes of the non cooperative mode of entry game are NN, GG, NG, while GN can be ruled out, as the small size of country II discourages the firm 1 from entering it. Firm 2 from the small country in NN will undoubtedly be the smaller producer. This will also be the case in GG, since firm 1 due to the cost of internal
technology transfer will have a cost advantage in the large market and thus would be larger than the rival.

**Insert Figure 6 here**

In Figure 6, we present simulations results. When we restrict ourselves to \(s>0.5\) and \(\sigma=0.5\), we only study the upper left part of the matrix. As mentioned above firm 1 will have the highest profit under GG. This is also the case under NG, unless the difference between the size of the two markets is rather small and \(\tau\) is high. We have illustrated this case in Figure 6 where firm 2 has the highest profit for the value \(s=0.7\). This is solely due to a strategy shifting effect that makes firm 2 profits jump when firm 1 finds it optimal to not invest in country 2 as this country is too small, allowing firm 2 to be a monopolist in its home market. However as we increase the relative size of market 1 further, profits for firm 2 at home falls faster and firm 1 is once again the one with the highest profits.

**Insert figure 7 here**

In Figure 7, we simulate the whole game, where the right hand matrix is the status quo game while the left hand matrix includes the acquisition strategy. The equilibrium strategy A1 says that firm 1 acquires firm 2, and vice versa for A2. Once again, focusing on the case where \(\sigma=0.5\), we see that acquisition in this case is only the equilibrium if NG is the status quo equilibrium. If NN is the status quo equilibrium, then acquisition costs are too high to exceed the profits derived from being a pure national monopolist. However, if we allow for technology asymmetries, this can easily change.

**Result 3**

In a context defined by market size asymmetry with technological symmetry, if the status quo is NN or GG the acquirer will certainly be the firm from the large country, while if in the status quo there is only one MNE (NG) the acquirer may be the firm from the small country only if the market size asymmetry is small and the costs of internal technology transfer are low.

**Technological asymmetry with market size symmetry \((s=0.5, \sigma>0.5)\)**

If \((s=0.5, \sigma>0.5)\) the leading firm has a greater incentive to invest abroad due to lower variable unit cost \((LHS \ Eq.(19) > LHS \ Eq.(20))\). The possible outcomes of the non cooperative
status quo game are NN, GG and GN, while NG can be ruled out since firm 1 has the better technology and thus the condition for becoming an MNE is less stringent for this firm (see the horizontal mid-line in Figures 6 and 7 for confirmations derived through simulations). Note that we have no external spillovers, so we are not allowing FDI for technology sourcing.

**Result 4**

The acquirer, in a context defined by technological asymmetry and market size symmetry, will certainly be the technological leader.

If the status quo is NN or GG, firm 1 (with the better technology) will be larger (i.e have higher profits) than firm 2 given its lower unit cost. If there is a one way greenfield investment that can only be the case of the leader reinforcing its position via FDI. Thus if there is an acquisition the technological leader is going to be the acquirer (once again consult Figure 7).

*Market size and technological asymmetries I (s<0.5, σ>0.5) Leader from the small country (lower half of the matrix)*

Firm 1 is the technological leader and is based in the small country. Both market size and technological effects concur to stimulate firm 1 to become an MNE. The possible outcomes are NN, GG, GN, while NG can be ruled out since the FDI condition is more restrictive for firm 2 than for firm 1. When the status quo is GG and we have low technology transfer costs and/or a high technology gap ($τσ > (1 − σ)$) if there is an acquisition that will be made by the leader of the small country buying the laggard in the large country. If however the status quo is NN or GN the result will depend on the balancing of different effects. In the NN case, it will depend on how important is the market size difference vs the technology difference. If the effect of the market size difference prevails, then the laggard from the large country will buy the technological leader based in the small market. In the GN case the outcome also depends on the size of the additional fixed cost the leader faces by going multinational. The lesson seems to be that a leading firm from a small country in order to save its independence (or to become a world leader) should be able to gain a sizeable technological lead over its competitors, and has to invest in making its technology more transferable across borders thus enhancing the benefits of establishing activities abroad.
Result 5

In the case of a technology leader from a small country, if the status quo is GG and we have low technology internal transfer costs and/or a high technology gap the acquirer will be the leader from the small country. If however the status quo is NN or GN both outcomes are possible.

Market size and technological asymmetries II \((s>0.5, \sigma>0.5)\) Leader from the large country (upper half in the matrix)

Firm 1 is the technological leader and is based in the large country. Market size and technological effects run in the opposite direction. All the four outcomes are possible (NN, GG, GN, GG). If the status quo is NN, firm 1 will have a larger status quo profit; that is also the case in the GG outcome (see Figures 6 and 7 for illustrations). In the case of one way FDI, if the potential MNE is firm 1 (the GN case) here too firm 1 will have a larger status quo profit. However, if the incentive from a large host market size prevail (the NG case) due to the contrasting effect from technology and market size difference, we cannot have a clear reply on which firm will have the largest status quo size.

Result 6

In the case of a technology leader from a large country, under rather general conditions, this firm will be the acquirer in case of a cross border take-over.

7. Conclusions

In the theoretical industrial organisation literature, the study of why firms decide to enter a foreign market through greenfield investment or M&As is in an infant stage. So far, no study has succeeded in identifying what kind of firms chooses to make a cross border acquisition and what kind of firms chooses instead to be acquired by foreign firms. In this paper we apply a simple bargaining model to determine the identity of the acquirer, in a setting where firms from different countries differ with respect to technology and countries differ with respect to size. This way, we are able to analyse whether e.g. technology leaders from small countries may find it optimal to acquire technology laggards in large countries, or vice versa.

Our model contains important features that seem to play a pivotal role in the choice between conducting an acquisition or establishing a new subsidiary abroad through greenfield

---

16 We have \(\pi_1^{NN} > \pi_2^{NN}\) which implies \(\pi_1^{GN} > \pi_2^{NN}\) if the status quo is GN.
investment. We consider both the gains from implementing a best practice technology and potential synergy effects in addition to knowledge transfer costs and acquisition costs associated with a merger. Empirical studies show that such acquisition costs can be surprisingly high, leading to low profits from acquisitions.

Our analysis shows that the acquiring firm is always the one that would have gained the highest profit if an acquisition was not possible. In fact we find that the equilibrium acquisition price reflects the target firm potential for growth. If countries are of similar sizes, the technology leader will thus always be the acquirer. If firms have equally productive technologies but countries differ in size, it is possible that the firm from the small country will acquire the firm from the large country since a large foreign market gives a strong incentive to invest abroad. Thus the firm form the small country would choose to go multinational while the other firm may remain purely national. In this case, if the market size asymmetry is small and the costs of internal technology transfer are low, the small country firm will have the highest alternative profit.

When firms and countries are completely symmetric, we show that an acquisition must generate strong synergy effects in order to be more profitable than a strategy where both firms remain purely national. However, a prisoner’s dilemma structure may force both firms to invest abroad, and in that case, an acquisition may be more profitable even without synergy effects.

Our future research will continue analysing the consequences of imposing both technology and market size asymmetries. Furthermore, we will investigate possible policy implications. Here, it is natural to ask whether governments can find it optimal to block acquisitions in order to avoid the establishment of monopolies, even though acquisitions may improve production technology through knowledge transfer.
<table>
<thead>
<tr>
<th></th>
<th>No Entry</th>
<th>Greenfield</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FIRM 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Entry</td>
<td>(\pi_1^{NN}, \pi_2^{NN})</td>
<td>(\pi_1^{NG}, \pi_2^{NG})</td>
</tr>
<tr>
<td>Greenfield</td>
<td>(\pi_1^{GN}, \pi_2^{GN})</td>
<td>(\pi_1^{GG}, \pi_2^{GG})</td>
</tr>
</tbody>
</table>

Table 1 Payoff matrix in the constrained mode of entry game
Figure 1a: Regions defining equilibrium outcomes in the \((s, \sigma)\) plane with \(F=1.5\)

Figure 1b: Regions defining equilibrium outcomes in the \((s, \sigma)\) plane with \(F=0.5\)
Figure 2: Changes in the regions defining equilibrium outcomes in the $(s, \sigma)$ plane with an increase in $\tau$. 
Figure 3: Nash cooperative solution (i.e. equilibrium bid) in the case of firm 1 acquiring firm 2
Figure 4: Firm characteristics in the \((s, \sigma)\) space

- Firm 1: Technology leader from the large country
- Firm 2: Technology lagger from the small country

<table>
<thead>
<tr>
<th>s</th>
<th>0.5</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>0.5</th>
<th></th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>\sigma</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 5: Changes in the regions defining equilibrium outcomes in the \( (\tau, F) \) plane with an increase in \( a \)
**Figure 6: Status Quo Equilibrium with information on the firm with the highest profit**

Positive values: Firm 1 profit > Firm 2 profit  
Equilibrium strategies: NG  NN  GN  GG

<table>
<thead>
<tr>
<th>s</th>
<th>0.5</th>
<th>0.50</th>
<th>0.55</th>
<th>0.60</th>
<th>0.65</th>
<th>0.70</th>
<th>0.75</th>
<th>0.80</th>
<th>0.85</th>
<th>0.90</th>
<th>0.95</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>0.23</td>
<td>0.48</td>
<td>0.74</td>
<td>0.99</td>
<td>1.24</td>
<td>1.50</td>
<td>1.75</td>
<td>2.00</td>
<td>2.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.85</td>
<td>0.21</td>
<td>0.45</td>
<td>0.69</td>
<td>0.93</td>
<td>1.17</td>
<td>1.41</td>
<td>1.65</td>
<td>1.90</td>
<td>2.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>0.15</td>
<td>0.39</td>
<td>0.62</td>
<td>0.85</td>
<td>1.10</td>
<td>1.36</td>
<td>1.61</td>
<td>1.86</td>
<td>2.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.75</td>
<td>0.07</td>
<td>0.29</td>
<td>0.51</td>
<td>0.83</td>
<td>1.09</td>
<td>1.35</td>
<td>1.62</td>
<td>1.87</td>
<td>2.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.7</td>
<td>-0.05</td>
<td>0.32</td>
<td>0.57</td>
<td>0.82</td>
<td>1.08</td>
<td>1.34</td>
<td>1.61</td>
<td>1.87</td>
<td>2.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.65</td>
<td>0.05</td>
<td>0.30</td>
<td>0.55</td>
<td>0.80</td>
<td>1.05</td>
<td>1.30</td>
<td>1.55</td>
<td>1.80</td>
<td>2.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>0.03</td>
<td>0.28</td>
<td>0.53</td>
<td>0.78</td>
<td>1.03</td>
<td>1.29</td>
<td>1.54</td>
<td>1.79</td>
<td>2.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.55</td>
<td>0.02</td>
<td>0.27</td>
<td>0.52</td>
<td>0.77</td>
<td>1.02</td>
<td>1.27</td>
<td>1.52</td>
<td>1.77</td>
<td>2.02</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 7: The full game**

Positive values: Acquisition equilibrium  
Equilibrium strategies: A1  A2  NO

<table>
<thead>
<tr>
<th>s</th>
<th>0.5</th>
<th>0.50</th>
<th>0.55</th>
<th>0.60</th>
<th>0.65</th>
<th>0.70</th>
<th>0.75</th>
<th>0.80</th>
<th>0.85</th>
<th>0.90</th>
<th>0.95</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>1.32</td>
<td>1.53</td>
<td>1.74</td>
<td>1.95</td>
<td>2.17</td>
<td>2.38</td>
<td>2.60</td>
<td>2.81</td>
<td>3.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.85</td>
<td>1.27</td>
<td>1.47</td>
<td>1.68</td>
<td>1.88</td>
<td>2.08</td>
<td>2.28</td>
<td>2.48</td>
<td>2.68</td>
<td>2.88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>1.19</td>
<td>1.39</td>
<td>1.58</td>
<td>1.78</td>
<td>1.98</td>
<td>2.18</td>
<td>2.38</td>
<td>2.58</td>
<td>2.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.75</td>
<td>1.08</td>
<td>1.27</td>
<td>1.47</td>
<td>1.67</td>
<td>1.87</td>
<td>2.07</td>
<td>2.27</td>
<td>2.47</td>
<td>2.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.7</td>
<td>1.00</td>
<td>1.20</td>
<td>1.40</td>
<td>1.60</td>
<td>1.80</td>
<td>2.00</td>
<td>2.20</td>
<td>2.40</td>
<td>2.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.65</td>
<td>0.95</td>
<td>1.15</td>
<td>1.35</td>
<td>1.55</td>
<td>1.75</td>
<td>1.95</td>
<td>2.15</td>
<td>2.35</td>
<td>2.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>0.90</td>
<td>1.10</td>
<td>1.30</td>
<td>1.50</td>
<td>1.70</td>
<td>1.90</td>
<td>2.10</td>
<td>2.30</td>
<td>2.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.55</td>
<td>0.85</td>
<td>0.95</td>
<td>1.15</td>
<td>1.35</td>
<td>1.55</td>
<td>1.75</td>
<td>1.95</td>
<td>2.15</td>
<td>2.35</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Status Quo Equilibrium with information on the firm with the highest profit

Positive values: Firm 1 profit > Firm 2 profit  
Equilibrium strategies: NG  NN  GN  GG

<table>
<thead>
<tr>
<th>s</th>
<th>0.5</th>
<th>0.50</th>
<th>0.55</th>
<th>0.60</th>
<th>0.65</th>
<th>0.70</th>
<th>0.75</th>
<th>0.80</th>
<th>0.85</th>
<th>0.90</th>
<th>0.95</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>-5.00</td>
<td>-0.10</td>
<td>0.20</td>
<td>0.30</td>
<td>0.40</td>
<td>0.50</td>
<td>0.60</td>
<td>0.70</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.85</td>
<td>-5.00</td>
<td>-0.10</td>
<td>0.20</td>
<td>0.30</td>
<td>0.40</td>
<td>0.50</td>
<td>0.60</td>
<td>0.70</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>-5.00</td>
<td>-0.10</td>
<td>0.20</td>
<td>0.30</td>
<td>0.40</td>
<td>0.50</td>
<td>0.60</td>
<td>0.70</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.75</td>
<td>-5.00</td>
<td>-0.10</td>
<td>0.20</td>
<td>0.30</td>
<td>0.40</td>
<td>0.50</td>
<td>0.60</td>
<td>0.70</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.7</td>
<td>-5.00</td>
<td>-0.10</td>
<td>0.20</td>
<td>0.30</td>
<td>0.40</td>
<td>0.50</td>
<td>0.60</td>
<td>0.70</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.65</td>
<td>-5.00</td>
<td>-0.10</td>
<td>0.20</td>
<td>0.30</td>
<td>0.40</td>
<td>0.50</td>
<td>0.60</td>
<td>0.70</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>-5.00</td>
<td>-0.10</td>
<td>0.20</td>
<td>0.30</td>
<td>0.40</td>
<td>0.50</td>
<td>0.60</td>
<td>0.70</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.55</td>
<td>-5.00</td>
<td>-0.10</td>
<td>0.20</td>
<td>0.30</td>
<td>0.40</td>
<td>0.50</td>
<td>0.60</td>
<td>0.70</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

sigma

sigma
Appendix 1

The profits of the two firms in the different market configurations are:

\[ \pi_{1,NN}^{N} = (sa - q_{1,l})q_{1,l} - (c_{0} - \sigma)q_{1,l} \]  

A1

\[ \pi_{2,NN}^{N} = ((l-s)a - q_{2,u})q_{2,u} - (c_{0} - (1-\sigma))q_{2,u} \]  

A2

\[ \pi_{1,NG}^{N} = (sa - (q_{1,l} + q_{2,l}))q_{1,l} - (c_{0} - \sigma)q_{1,l} \]  

A3

\[ \pi_{2,NG}^{N} = ((l-s)a - q_{2,u})q_{2,u} - (c_{0} - (1-\sigma))q_{2,u} + (sa - (q_{1,l} + q_{2,l}))q_{2,l} - (c_{0} - \tau(1-\sigma))q_{2,l} - F \]  

A4

\[ \pi_{1,GN}^{N} = (sa - q_{1,l})q_{1,l} - (c_{0} - \sigma)q_{1,l} + ((l-s)a - (q_{1,u} + q_{2,u}))q_{1,u} - (c_{0} - \tau\sigma)q_{1,u} - F \]  

A5

\[ \pi_{2,GN}^{N} = ((l-s)a - (q_{1,u} + q_{2,u}))q_{2,u} - (c_{0} - (1-\sigma))q_{2,u} \]  

A6

\[ \pi_{1,GG}^{N} = (sa - (q_{1,l} + q_{2,l}))q_{1,l} - (c_{0} - \tau(1-\sigma))q_{2,l} + ((l-s)a - (q_{1,u} + q_{2,u}))q_{2,u} - (c_{0} - (1-\sigma))q_{2,u} - F \]  

A7

\[ \Pi_{1,41}^{A} = (V_{1,41}^{A} - T_{1}) - B_{1} \]  

A9

\[ \Pi_{2,42}^{A} = (V_{2,42}^{A} - T_{2}) - B_{2} \]  

A10

\[ V_{1,41}^{A} = (sa - q_{1,l})q_{1,l} - \left\{ c_{0} - \left( \max (\sigma, \tau(1-\sigma)) + \rho(\sigma(1-\sigma)) \right) \right\}q_{1,l} + \]  

\[ ((l-s)a - q_{1,u})q_{1,u} - \left\{ c_{0} - \left[ \max (\tau\sigma, (1-\sigma)) + \rho(\sigma(1-\sigma)) \right] \right\}q_{1,u} \]  

A11

\[ V_{2,42}^{A} = (sa - q_{2,l})q_{2,l} - \left\{ c_{0} - \left( \max (\sigma, \tau(1-\sigma)) + \rho(\sigma(1-\sigma)) \right) \right\}q_{2,l} + \]  

\[ ((l-s)a - q_{2,u})q_{2,u} - \left\{ c_{0} - \left[ \max ((1-\sigma), \tau\sigma) + \rho(\sigma(1-\sigma)) \right] \right\}q_{2,u} \]  

A12
References


Horn, H. and L. Persson (2001)“The equilibrium ownership of an international oligopoly” International Journal of Industrial Organisation (53) 307-333


