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Abstract

This paper studies the effect of technology spillovers on the entry decision of a multinational enterprise into a foreign market. Two alternative entry modes for a foreign direct investment are considered: Greenfield investment versus acquisition. We find that with quantity competition a spillover makes acquisitions less attractive, while with price competition acquisitions become more attractive. Asymmetric information about potential spillovers always reduces the number of acquisitions independently of whether the host country or the entrant has private information. Interestingly, we find that asymmetric information always hurts the entrant, while it sometimes is in favor of the host country.

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1 Introduction

When a multinational enterprise (MNE) enters a foreign market this can cause external effects on domestic firms. Foreign direct investment (FDI) may, for example, improve domestic know how through technology spillovers. If such a technology spillover benefits a company which is a direct competitor to the multinational firm, this externality naturally is not in the interest of the MNE. Strategically there are two key decisions for the multinational enterprise: The mode of foreign entry and the level of control over the local subsidiary. The level of control is associated with the ownership structure.[1] This in turn certainly may be influenced by the prospect of a technology spillover since engagement of a local partner may be the reason for the externality to come up at all.[2] What is the effect of a technology spillover on the choice of entry mode between setting up a new venture via greenfield investment or acquisition of a local competitor?

This paper contributes to answering this question by analyzing the effect of technology spillovers on the choice of entry mode. In particular, we ask two questions: What is the effect of technology spillovers on the entry mode choice under different forms of competition, i.e. quantity competition or price competition? How affects asymmetric information about a potential spillover the choice of entry mode? It is very likely that the multinational enterprise and a local competitor have different information concerning such intangible assets like know how and technology. The MNE, for example, might have private information on whether or not local workers will be employed and get in contact with sensible information. On the other hand, there may be private information for the domestic firm whether its workers or managers are well enough trained to be capable of employing advanced technologies.

Foreign direct investment as a channel of technology transfer has been

[1] The notion of ownership as entitling the owner with the residual control rights over the asset has been put forward by Grossman and Hart [1986] and Hart and Moore [1990].

[2] In Müller and Schnitzer [2002] we analyze the effect of a potential spillover on the incentive to transfer technology and how incentives can be controlled through the ownership structure in international joint ventures.

analyzed theoretically, for example, in Findlay [1978], Das [1987] or Wang and Blomström [1992].[3] One of their arguments is that the technological progress in a developing country depends positively on the technology gap and on the share of FDI in the capital stock. The empirical literature on the transfer of know how and technology across borders identifies mixed evidence on the impact of FDI on the productivity of domestic firms.[4] Kokko [1994], Borensztein, De Gregorio and Lee [1998] and Xu [2000] found evidence that positive spillovers are more likely generated, if the technology gap is not too large and if there exists a minimum threshold of human capital.[5] Both of these findings are in line with the theoretical results of our model. On the other hand, there also exists evidence for negative spillovers from foreign investment on domestically owned plants, e.g. Haddad and Harrison [1993], Aitken and Harrison [1999] or Djankov and Hoekman [2000].[6] However, none of all these studies on technology transfer and spillovers makes a distinction for the choice of entry mode in FDI.

Even though the choice of entry mode is an important decision for the organizational form of foreign direct investment it has received relatively little attention in the economic literature. Empirically a number of potential factors influencing the choice of entry mode have been studied. Kogut and Singh [1998] found that with a greater cultural distance greenfield investment or joint ventures are more likely chosen than acquisition. For investment in the US there is evidence that large and diversified companies prefer acquisition as Caves and Mehra [1986] show. This finding gets support in Meyer

[3]For recent surveys on international technology transfer and spillovers see Saggi [2001] or Blomström and Kokko [1998].

[4]International trade can be a source of spillovers too. Coe and Helpman [1995], Coe Helpman and Hoffmaister [1997], and Lichtenberg and van Pottelsberghe de la Potterie [1998] find evidence that foreign trade partners' R&D influences domestic total factor productivity.

[5]Other studies which found positive effects from the presence of MNEs on the productivity of domestic firms include, for example, the early studies by Caves [1974], Globerman [1979] or Blomström [1986].

[6]Görg and Strobl [2001] review the empirical literature on multinational companies and productivity spillovers. They argue that the empirical methods used and whether cross-section or panel analysis is employed can have an effect on the empirical results.

[1998] for entry into Central and Eastern Europe. Hennart and Park [1993] found that greenfield investment is the prefered mode of entry for R&D intensive Japanese Firms for entry into the US. Their results suggest that acquisitions are used by investors with weak competitive advantages, while investors with strong advantages find that greenfield investment is a more efficient entry mode.[7] Both of these findings are supported by the theoretical results of our model. We show that acquisition is the efficient mode of entry when technologies are sufficiently similar, while greenfield investment is the prefered choice when the MNE possesses a very superior technology.

There are only a few theoretical papers dealing with the choice of entry mode in foreign direct investment. Buckley and Casson [1998], Görg [2000] and Müller [2001] analyze the effect of market structure and competition intensity on the choice of entry mode. Mattoo, Olarreaga and Saggi [2001] examine how the choice of entry mode affects the extend of technology transfer and the degree of competition in the host country.[8] These approaches, however, neither take account of the effect of technology spillovers nor of asymmetric information on the choice of entry mode.

In a recent paper, Das and Sengupta [2001] analyze the effect of asymmetric information about different payoff relevant variables on the formation of international mergers. In particular, they investigate two scenarios, one where a local firm has private information on market size and one where a foreign firm has private information on its own technology. Their main finding is that private information may be a hindrance to the formation of mergers. However, they assume that merger is the preferred mode of entry in case of full information. Hence, asymmetric information may result in fewer, but it cannot result in more mergers.

In contrast to their approach our model allows for both entry modes to be efficient in the first place. Moreover, we analyze the effect of asymmetric information over the same variable in both scenarios of private information. Therefore, we are able to examine the basic effect of a technology spillover

[7] Andersson and Svensson [1994] found similar results for Swedish multinational firms.

[8] See also Bjorvatn [2001] and Norbäck and Persson [2002] for theoretical models of the choice of entry mode.

on both types of entry mode and the effect of asymmetric information over the externality on the strategic entry choice. We consider a multinational enterprise in possession of a superior technology which can be employed in a greenfield investment. In this case a technology spillover can occur to the single local competitor thereby weakening the competitive advantage of the MNE. Alternatively the MNE could acquire its competitor and thereby avoid the prospect of a spillover. However, in this case only the inferior technology of the acquired company can be adopted.

The acquisition price and the profits for both firms concerning both entry modes are endogenously determined. Theses values which are crucial to the entry mode choice obviously depend on market characteristics, on the potential technology spillover, and on the technology difference between both firms. Interestingly, we find that the effect of a technology spillover on the entry mode choice crucially depends on the nature of competition. With quantity competition a technology spillover is a hindrance to acquisitions. However, with price competition and horizontally differentiated products we obtain exactly the opposite result. The effects of asymmetric information about a potential technology spillover on the entry mode choice are independent of the form of competition. We also find that private information indeed has a negative effect on the overall acquisition activity. In contrast to Das and Sengupta [2001] we show that under certain conditions private information may result in acquisitions which would not have taken place under full information. Finally, we find that the multinational firm ex ante prefers full information rather than private information. This is particularly surprising given the fact that the MNE makes the acquisition offer and should thereby be able to take advantage of its private information. The domestic firm, however, is better off with private information about a potential spillover.

The rest of this paper is organized as follows. The next section sets up the basic model. In section 3, we determine the optimal mode of entry under full information. Section 4 and section 5 analyze the entry mode choice under two scenarios of asymmetric information about a potential technology spillover. In section 6, we compare the different informational scenarios from an ex ante perspective. The final section discusses extensions and concludes.

2 The Model

Consider a multinational enterprise (MNE) that enters a foreign market. This market is currently served by a single domestic firm (HC). To enter the market the multinational firm 2 can either acquire the domestic firm 1 or set up a new venture via greenfield investment. Apart from the multinational firm there is no other potential entrant. Both firms $i = 1, 2$ produce at constant marginal cost c_i with no fixed cost. The entering MNE employs a superior technology than the domestic firm 1 ($\bar{c}_1 > c_2 \geq 0$). This assumption reflects the fact that a domestic firm located in a country like in Central and Eastern Europe or a developing country has no access to advanced technologies.

The presence of a multinational firm may have an impact on the technological capabilities of the domestic firm by inducing a technology spillover. A greenfield investment might, for example, result in a turnover of trained workers from the multinational firm to the domestic firm thereby improving the know how of the domestic firm. There are many other venues one can think of for the flow of information or know how. Of course an acquisition could also lead to a technology spillover. However, in our model an acquisition can only cause a spillover into another industry since there exists no other firm. A technology spillover in our model simply results in a reduction of the production cost for the domestic firm 1 to $\underline{c}_1$ such that $\bar{c}_1 > \underline{c}_1 \geq c_2 \geq 0$.[9] The spillover occurs with probability $q \in (0, 1)$, but the parties may have private information on whether or not greenfield investment does lead to a technology spillover. We assume that, if a new venture is set up, information is revealed and both parties compete in quantities under full information.[10]

The market demand is represented by a simple linear demand function $p = a - x$, where the total quantity sold is denoted by x. In order for all profits to be non-negative we impose the following restriction on market size:

$$a \geq 2\bar{c}_1 - c_2.$$

[9] Thus, the technology spillover can result in a full reduction of the production cost in the sense that $\underline{c}_1 = c_2$ or only a partial reduction $\underline{c}_1 > c_2$.

[10] This is for simplicity. Otherwise we get results for incomplete information competition which simply would make the model more complicated.

When entering by acquisition the entrant has to use the acquired firm's technology $\bar{c}_1$.[11] If instead the entrant sets up a new venture he can implement the superior technology c_2. For simplicity the investment cost for a greenfield investment is assumed to be $k = 0$. Hence, by assumption greenfield investment is always a viable opportunity and market entry by MNE will always occur.[12] The entry cost in case of acquisition is equal to the acquisition price since no other cost like an adaptation cost is involved. This acquisition price, P_A, is endogenously determined. The multinational enterprise can make a take-it-or-leave-it offer to acquire firm 1.[13]
The time structure of the entry game is the following:
At stage 1, firm 2 (MNE) can choose between making a take-it-or-leave-it offer to acquire firm 1 (HC), greenfield investment or no market entry.
At stage 2, if firm 2 has made an offer, the incumbent firm 1 can accept or reject the offer.
At stage 3, firm 2 enters via greenfield investment in case firm 1 has turned the offer down.
At stage 4, firms enter competition and profits are realized.

Solving this game by backwards induction yields the sub-game perfect equilibrium of the bargaining game. The exact value of the acquisition offer depends on the informational structure and on the nature of competition.

With respect to stage 4 we will analyze in the following section the effect of a technology spillover on the entry mode choice for quantity competition and besides that for price competition. Therefore, we consider a standard model of horizontal product differentiation. Consumers are uniformly distributed along the unit interval [0,1] with density 1. They receive the surplus s from consumption of the good but incur a linear transportation cost t. HC is

[11] We could also assume that the entrant can implement its own technology by adapting the production facility which would involve additional costs. This would give us the same qualitative results.

[12] Otherwise for $k > 0$ greenfield investment might sometimes not be viable and therefore no credible option which in turn can prevent any entry at all as shown in Müller [2001].

[13] This constitutes a lower bound for the acquisition price. Other bargaining frameworks, where HC has bargaining power, too, obviously would lead to a higher acquisition price and thus shift preferences of the MNE in favor of greenfield investment.

located at $x = 0$.MNE can choose between acquisition of HC or a greenfield investment in $x = 1$.

3 Entry Mode Choice under Full Information

To begin with, consider the full-information case where both parties know whether a technology spillover occurs or not. Since greenfield investment is by assumption always viable the acquisition price P_A in equilibrium is equal to firm 1's post-greenfield entry profit denoted by $\pi_1(\bar{c}_1, c_2)$ if no spillover occurs or $\pi_1(\underline{c}_1, c_2)$ in case of a spillover. Thus, MNE either chooses acquisition at price P_A equal to firm 1's greenfield profit or greenfield investment at $k = 0$ otherwise.

Definition 1 $\bar{\pi}_i = \pi_i(\bar{c}_1, c_2)$, $\underline{\pi}_i = \pi_i(\underline{c}_1, c_2)$, $\pi_1^M = \pi_1^M(\bar{c}_1)$.

Without a technology spillover acquisition at price $P_A = \bar{\pi}_1$ takes place whenever

$$\pi_1^M \geq \bar{\pi}_1 + \bar{\pi}_2. \tag{1}$$

In case of a technology spillover acquisition at price $P_A = \underline{\pi}_1$ takes place whenever

$$\pi_1^M \geq \underline{\pi}_1 + \underline{\pi}_2. \tag{2}$$

How are the profits of both parties and as a result the choice of entry mode affected by a technology spillover? The spillover only occurs when greenfield investment is chosen, but it can be avoided by acquisition of the local competitor. Hence, acquisition has the advantage of becoming a monopolist and avoiding a potential spillover, but it has the disadvantage of a restriction to an inferior technology. With greenfield investment the technological advantage can be exploited, but then there is competition and also the possibility of a technology spillover. As a result of this it is not clear in which direction these effects influence the entry mode choice. It could be argued that acquisition becomes more attractive if a spillover occurs than in a situation without a technology spillover since then there is less need for an acquisition. Thus,

more acquisitions should be expected in case of a technology spillover.[14]

Quantity competition

As a consequence of a spillover on the one hand the acquisition price increase, while on the other the greenfield profit for MNE decreases since obviously $\underline{\pi}_1 > \bar{\pi}_1$ and $\bar{\pi}_2 > \underline{\pi}_2$. A priori it is not clear which of these two effects dominates. For some parameter constellations the effect on the greenfield profit is stronger than the effect on the acquisition price, while for other parameters it is the other way round.[15] Surprisingly, however, we can show that even if the effect on the greenfield profit dominates, there is an unambiguous tendency concerning the impact of a spillover on the entry mode choice: A technology spillover results in fewer acquisitions.

Proposition 1 *With quantity competition a technology spillover reduces the parameter space for which acquisition is the optimal entry mode.*

Proof: See Appendix.

Hence, with quantity competition a technology spillover results in fewer acquisitions compared to a situation without spillovers. The intuition for this interesting result is the following. If the effect on the acquisition price dominates, the impact on the entry mode choice is rather natural. Moreover, the effect on the greenfield profit for MNE dominates only if the difference in technologies is relatively large. As a consequence there is no further incentive to acquire since the monopoly profit then is comparably small relative to the greenfield profit for MNE. Therefore, even though the negative effect of a spillover on the greenfield profit sometimes dominates, this effect is never strong enough to change the entry mode choice from greenfield investment (without a spillover) to acquisition (with a spillover). Consequently, condition (2) is more restrictive than condition (1).

[14] In our model, either acquisition is chosen or not, in which case there is greenfield investment. Thus, the number of acquisitions is either 1 or 0. By more acquisitions we mean that the condition for which acquisition takes place is less restrictive if a technology spillover occurs.

[15] See Lemma 3 in the Appendix.

Price competition

How robust is this result that a spillover, which could be avoided by acquisition, results in fewer acquisitions? Suppose firms were to compete in prices, each producing a horizontally differentiated product. Again, a spillover increases the acquisition price on the one hand, but the greenfield profit for MNE decreases on the other hand, i.e. $\underline{\pi}_1 > \bar{\pi}_1$ and $\bar{\pi}_2 > \underline{\pi}_2$. In contrast to the case of quantity competition the effect of a spillover on the greenfield profit (nearly) always dominates the effect on the acquisition price.[16] Furthermore, this effect is strong enough to change the entry mode choice from greenfield investment (without a spillover) to acquisition (with a spillover).

Proposition 2 *With price competition and horizontally differentiated products a technology spillover extends the parameter space for which acquisition is the optimal entry mode.*

Proof: See Appendix.

Hence, with price competition a technology spillover results in more acquisitions compared to a situation without spillovers. Since the effect on the greenfield profit for MNE dominates, the impact on the entry mode choice is fairly obvious. More formally, with price competition and horizontally differentiated products condition (1) is more restrictive than condition (2). Therefore, it is exactly the opposite result than with quantity competition.

Thus, the overall effect of a technology spillover on the choice of entry mode crucially depends on the nature of competition. The opposing effects of a spillover are caused by the fact that products are either strategic substitutes or strategic complements. A technology spillover has basically two effects: A direct *cost reducing effect* for HC and indirect *competition effects* on both firms. With quantity competition products are strategic substitutes. As a consequence of this the two effects on the profit of HC reinforce and dominate the competition effect on MNE. Under price competition and horizontally differentiated products, prices are strategic complements. Hence, the competition effect of a technology spillover on the profit for MNE dominates.

[16] See Lemma 4 in the Appendix.

4 Entry Mode Choice when the Host Country Firm has Private Information about Potential Technology Spillovers

Suppose the domestic firm has private information concerning the potential technology spillover. The host country firm is likely to know whether its workers or managers will be capable of learning and applying new technologies or know how. The multinational firm does not know whether a spillover will occur in case of a greenfield investment but believes that firm 1's production cost will be $\underline{c}_1$ or $\bar{c}_1$ with probabilities q and $(1-q)$ respectively. If greenfield investment is chosen, information is revealed. Therefore, we then obtain the standard results of the duopoly game.

In case of acquisition there is asymmetric information about the potential spillover. The uninformed multinational firm makes a take-it-or-leave-it offer and becomes a monopolist in this market if the offer is accepted. The domestic firm 1 accepts any offer which gives at least the profit that can be achieved in competition if greenfield investment would take place. If the domestic firm rejects the offer, MNE enters via greenfield investment and firms compete in quantities under full information. We obtain the following result concerning the equilibrium acquisition offer:[17]

Lemma 1 *The equilibrium acquisition offer is*

(a) $P_A = \underline{\pi}_1$ *if condition (2) is fulfilled and* $q \geq \hat{q}$,

(b) $P_A = \bar{\pi}_1$ *if condition (2) is fulfilled and* $q < \hat{q}$,
or if only condition (1) is fulfilled,

(c) $P_A = 0$ *if neither condition (1) nor (2) is fulfilled,*

where $\hat{q} = \frac{\underline{\pi}_1 - \bar{\pi}_2}{\pi_1^M - \bar{\pi}_1 - \underline{\pi}_2}$.

Proof: See Appendix.

[17] Lemma 5, in the Appendix, determines the equilibrium acquisition offer if firms compete in prices.

Intuitively, if acquisition is always efficient under full information, i.e. condition (2) is met, and the probability of a spillover is high, i.e. $q \geq \hat{q}$, the uninformed multinational makes a high offer $P_A = \underline{\pi}_1$ which is always accepted. In this case the potential loss of making a too high offer in case there is no potential for a spillover is outweighed by the benefits of becoming a monopolist (and avoiding the spillover) when actually a spillover would have occured. On the other hand, if the probability of a spillover is small, i.e. $q < \hat{q}$, it is in a sense too costly to offer a high acquisition price. Therefore, the multinational makes a low offer $P_A = \bar{\pi}_1$. Moreover, if an acquisition is efficient if no spillover occurs but inefficient in case of a spillover [i.e. condition (1) met but (2) violated] the multinational always makes a low offer $P_A = \bar{\pi}_1$. A low offer is accepted only in case there is no potential for a spillover and otherwise it's rejected. Finally, if acquisition is never efficient, i.e. the technology difference is too large, the multinational prefers not to make an offer but rather enters competition via greenfield investment.

The overall effect of HC's private information about a potential technology spillover on the entry mode is the following.

Proposition 3 *Private information for HC about a potential technology spillover reduces the parameter space for which acquisition is the optimal entry mode.*

Proof: See Appendix.

Private information for HC results in fewer acquisitions compared to full information.[18] This follows immediately from the determination of the equilibrium acquisition offer. MNE makes a high offer only if acquisition is efficient anyway. Hence, a high offer has no effect on the overall acquisition activity but on both parties' payoffs. This is also true for the case of no offer, $P_A = 0$, where acquisition is always inefficient even with full information. If the multinational makes a low offer, $P_A = \bar{\pi}_1$, this is accepted only if no spillover occurs. Otherwise a low offer is rejected. This has no effect

[18] In the Appendix, we prove that this result is obtained also for the case of price competition and horizontally differentiated products.

on the acquisition activity if only condition (1) is fulfilled. However, the multinational sometimes enters via greenfield investment even though with full information acquisition would be efficient, i.e. if condition (2) is met. We can summarize, private information for HC about a potential technology spillover has a negative effect on the overall acquisition activity.

For a given spillover, after the acquisition offer has been made and entry took place, the question is: which party has an advantage or a disadvantage because of the asymmetric information? It should be expected that the informed party gains from having an informational advantage. But as the following result shows this is not always the case:

Proposition 4 *Compared to full information HC gains from private information if condition (2) is fulfilled and $q \geq \hat{q}$, if there is no potential for a spillover.*

Proof: See Appendix.

The intuition for this result is pretty straightforward. HC can take advantage from private information only if MNE offers more than the actual post greenfield profit. This happens if the multinational expects a spillover to occur with a high probability and therefore makes a high offer, but there is no potential for a spillover, i.e. a spillover would not have occured. As Lemma 1 shows, a high offer is only made if acquisition is efficient in any case, i.e. (2) is fulfilled. Therefore, the technological difference and/or the potential technology spillover should not be too large. In all other situations HC receives a payoff which is equal to its post greenfield entry profit.

Considering the situation for the multinational firm we find that the MNE always loses compared to full information if HC gains. Furthermore, the multinational sometimes forgoes an efficient acquisition if a spillover is expected to be not very likely but it actually occurs.

Proposition 5 *Compared to full information MNE suffers from private information for HC if condition (2) is fulfilled and $q < \hat{q}$ ($q \geq \hat{q}$), if there is (no) potential for a spillover.*

Proof: See Appendix.

Acquisition is efficient in any case and thus condition (2) is fulfilled only if the difference in technologies and/or the technology spillover is sufficiently small. Otherwise, if the technology difference or the spillover is too large, the monopoly profit is too small relative to the sum of the acquisition price and the greenfield profit for MNE. Thus, private information for HC about the potential technology spillover may have an effect on payoffs only if the technological difference and therefore the potential spillover is not too large. Compared to the full information case MNE sometimes makes an offer which is too high given that no spillover would have occured. Or MNE sometimes makes an offer which is too low given that a spillover actually occurs. In the former case the domestic firm gains from its private information, while in the latter case it makes no difference to HC.

5 Entry Mode Choice when the Multinational Enterprise has Private Information about Potential Technology Spillovers

Now suppose that the multinational enterprise has private information about the potential technology spillover. MNE might, for example, know whether local workers are going to get in contact with sensible information concerning the production technology that might be of value to the domestic competitor. The domestic firm does not know whether a spillover will occur in case of a greenfield investment, but believes that its production cost will be $\underline{c}_1$ or $\bar{c}_1$ with probabilities q and $(1-q)$ respectively. Again, if greenfield investment is chosen, information is revealed and both parties compete in quantities under full information.

The informed multinational makes a take-it-or-leave-it offer. By choosing an appropriate offer the MNE may signal whether there is potential for a spillover. In a pooling equilibrium information is not revealed by the offer. In this case the domestic firm accepts any offer which gives at least the expected post greenfield entry profit, i.e. $E[\pi_1] = q\underline{\pi}_1 + (1-q)\bar{\pi}_1$. In a separating

equilibrium information is revealed and the domestic firm can distinguish between both types of MNE, i.e with or without potential for a technology spillover. In this case the domestic firm accepts any offer which gives at least the respective post greenfield profit. Again, if the offer is rejected or if no offer is made, MNE enters via greenfield investment and firms compete in quantities under full information. The following result is obtained:

Lemma 2 *There exist three possible equilibria for the acquisition offer.*

1. *If* $\pi_1^M \geq E[\pi_1] + \bar{\pi}_2$ *there exists a* **pooling** *equilibrium where MNE offers* $P_A = E[\pi_1]$*, and this offer is accepted in equilibrium.*

2. *If* $\underline{\pi}_1 + \bar{\pi}_2 > \pi_1^M \geq \underline{\pi}_1 + \underline{\pi}_2$ *there exists a* **separating** *equilibrium, where MNE makes a high offer,* $P_A = \underline{\pi}_1$*, only if there is potential for a spillover. This offer is accepted in equilibrium. Otherwise no offer is made.*

3. *If* $\underline{\pi}_1 + \underline{\pi}_2 > \pi_1^M$ *there exists a* **pooling** *equilibrium where no offer is made.*

Proof: See Appendix.

The intuition for this result is the following. In pooling equilibrium *1.* information is not revealed since MNE makes the same offer, $P_A = E[\pi_1]$, independently of whether there is potential for a spillover or not. This occurs in equilibrium if it is profitable for both types of MNE to make such an offer.[19] If the multinational gains from such an offer only if there is potential for a spillover, information is revealed in separating equilibrium *2.* Since then HC can distinguish the types of MNE it will only accept an offer $P_A \geq \underline{\pi}_1$ if there is potential for a spillover. Therefore, the equilibrium offer is raised to

[19]Typically signalling games have many equilibria. In our case the problem is that several offers can be supported as a pooling equilibrium with different sets of beliefs. To be more precise, any offer $P_A \in (E[\pi_1], \underline{\pi}_1)$ can be supported as a pooling equilibrium. In these equilibria acquisition is more expensive and therefore the parameter space for which the respective equilibrium exists is more restricted compared to the one considered here. Thus, in a sense $P_A = E[\pi_1]$ constitutes a lower bound for the acquisition price.

$P_A = \underline{\pi_1}$ if there is potential for a spillover and otherwise the MNE makes no offer. Finally, in pooling equilibrium *3.* acquisition is not profitable for either type of MNE. Note that the proposed equilibria might exist at the same time. More precisely for certain parameter constellations the pooling equilibrium *1.* and the separating equilibrium *2.* or both pooling equilibria exist simultaneously.[20] The separating equilibrium *2.* and the pooling equilibrium *3.* are mutually exclusive.

How is the acquisition activity affected by private information for MNE about a potential technology spillover? From inspection of the equilibrium acquisition offers it follows that for certain parameter constellations an acquisition, which under full information would have been efficient, not takes place. This happens whenever the multinational firm makes no offer but (1) is fulfilled and a spillover occurs. However, as the following result claims, under certain conditions acquisition is chosen even though with full information the multinational firm would have chosen greenfield investment:

Proposition 6 *If condition (2) is not fulfilled, private information for MNE about a potential technology spillover extends the parameter space for which acquisition is the optimal entry mode compared to full information in case of pooling equilibrium 1., i.e.* $P_A = E[\pi_1]$.

Proof: See Appendix.

The intuition for this result is straightforward. If (2) is not fulfilled the MNE chooses greenfield investment under full information if a spillover occurs simply because acquisition would have been too expensive. With private information MNE offers a cheaper acquisition price, $P_A = E[\pi_1]$, in pooling equilibrium *1.* and this is always accepted. Thus, acquisition is chosen even if otherwise a spillover would have occured. Note, however, that this result holds only if this equilibrium is selected since for the relevant parameter constellation the pooling equilibria *1.* and *3.* coexist.

To summarize, we find that under certain conditions the acquisition activity is enhanced by private information for MNE. As already mentioned, on

[20] See Proof of Lemma 2 for a formal description.

the other hand, private information sometimes prevents efficient acquisitions. Despite of the opposing effects the overall effect of MNE's private information about a potential technology spillover on the entry mode is unambiguous.

Proposition 7 *Private information for MNE about a potential technology spillover reduces the parameter space for which acquisition is the optimal entry mode.*

Proof: See Appendix.

Thus, private information for MNE results in fewer acquisitions compared to full information.[21] The multinational enterprise sometimes makes no acquisition offer at all even though this would be efficient under full information. With full information acquisition is efficient if no spillover occurs and (1) is met. In the same situation but with private information for MNE no offer is chosen in case of separating equilibrium *2.* or pooling equilibrium *3.* The positive effect of private information on acquisition activity which was stated in Proposition 6 is more than compensated by these two negative effects.[22]

Which of the parties gains and which suffers from private information for MNE about a potential technology spillover for a given spillover? Again, it could be expected that the informed party can take advantage of its information. However, this must not be in general the case. In fact it can be exactly the opposite way with the uninformed HC gaining from asymmetric information. The reason for this result is that MNE sometimes offers more than the actual post greenfield profit to acquire HC.

Proposition 8 *Compared to full information HC (gains) suffers from private information for MNE in pooling equilibrium 1., i.e.* $P_A = E[\pi_1]$*, if there is (no) potential for a spillover.*

Proof: See Appendix.

[21] Again, this result is independent of the form of competition as shown in the Appendix.

[22] Furthermore, the problem of equilibrium selection should be remembered. The result of Proposition 7 is straightforward if instead of pooling equilibrium *1.* with $P_A = E[\pi_1]$ pooling equilibrium *3.* with $P_A = 0$ is considered in the respective parameter space.

The acquisition price $P_A = E[\pi_1]$ is too low compared to full information if a spillover occurs but it is too high given that no spillover would have occured. In all other situations HC receives a payoff which is equal to its post greenfield profit with full information independently of whether greenfield investment or acquisition takes place.

For the multinational firm it is exactly the other way round when the equilibrium acquisition offer is equal to $P_A = E[\pi_1]$. Thus, MNE might gain or suffer from having private information. But there are additional disadvantages:

Proposition 9 *Compared to full information*

(a) MNE gains (suffers) from private information in pooling equilibrium 1., i.e. $P_A = E[\pi_1]$, if there is (no) potential for a spillover, or

(b) MNE suffers from private information if condition (1) is fulfilled, if there is no potential for a spillover.

Proof: See Appendix.

The multinational firm takes advantage of its private information only if in pooling equilibrium *1.* a spillover would have occured. Otherwise MNE has a disadvantage in pooling equilibrium *1.* Moreover, in all other cases, if technologies are sufficiently similar, i.e. (1) fulfilled, and there is no potential for a spillover, MNE chooses greenfield investment even though acquisition would have been efficient. Hence, the multinational enterprises then suffers from its private information too. In all other situations the MNE achieves the same payoff as with full information.

Again, private information for MNE about the potential spillover may have an effect on payoffs only if the technological difference is sufficiently small. However, this is a bit different from the situation with private information for HC about the potential spillover. In some sense the circumstances for which private information may have an effect on payoffs are more limited if HC is privately informed than if MNE is privately informed. In the former situation asymmetric information may have an effect only for very similar

technologies (i.e. condition (2) fulfilled). In the latter it may have an effect also for not too similar technologies (i.e. condition (1) fulfilled).

6 Comparison of the Different Informational Scenarios from an Ex Ante Perspective

In this section, we compare the different informational scenarios from an ex ante perspective. This enables us to judge which of the described situations should be in the interest of the parties if they were able to choose between being informed or uninformed in the first place, i.e. before any other decisions are determined. A priori one might expect that it is always in the interest of either party to have private information on the potential technology spillover. At least from an ex ante perspective parties should be able to take advantage from being privately informed, even though ex post this must not be the case in general as we have already shown. However, the following result states that this is not the case for the multinational enterprise.

Proposition 10 *Ex ante MNE always (weakly) prefers full information over any kind of asymmetric information.*

Proof: See Appendix.

This is particularly surprising given the fact that the MNE proposes the acquisition offer and might thereby further exploit an informational advantage. What is the reason for this result? Intuitively, we can state that signalling its type is too costly for MNE in some sense from an ex ante perspective. In order to be able to separate the spillover inducing type from the one that has no potential for a spillover, MNE must refrain from announcing a positive acquisition offer if no spillover occurs even though this would be efficient. Moreover, MNE cannot separate in case an acquisition would only be efficient if there is no potential for a spillover since any positive offer can be profitably replicated by the spillover inducing type. To summarize, we can conclude that the multinational enterprise sometimes must forgo efficient acquisitions

and is therefore not able to take advantage of its private information. Obviously, private information for HC about the technology spillover cannot be in the interest of MNE.

With respect to the host country firm we obtain the more straightforward result that private information is prefered from an ex ante as well as from an ex post perspective.

Proposition 11 *Ex ante HC always (weakly) prefers to have private informations.*

Proof: See Appendix.

Intuitively, the domestic firm can take advantage of private information since there is no signalling cost involved. Some kind of signalling and information revealing takes place by rejection of an offer, which will only happen in case there is potential for a spillover but a low offer is made.

Obviously, there is a difference between the ex ante and the ex post preference towards the informational situation. This is not very surprising since a divergence in ex ante and ex post considerations is a common feature of many economic issues. What is surprising is the fact that the multinational firm would not choose to have private information about the potential technology spillover in the first place. In some sense MNE has the disadvantage of having to make an acquisition offer in both scenarios of asymmetric information.

7 Discussion and Conclusions

In the existing literature on FDI there is no well developed theory of the determinants of the choice between greenfield investment and acquisitions. Nevertheless, it is well recognized that this issue is very important both from a host country perspective and from the perspective of a multinational enterprise. As empirical evidence suggests, the strategic entry mode choice is affected by various firm specific and country specific factors. Among others the potential for technology spillovers seems to play an important role. We contribute to the literature by providing a simple theoretical model to analyze

the effects of technology spillovers on the choice of entry mode. In particular, we examined the effect of asymmetric information about the potential for a spillover on the entry decision.

First, we showed that under full information the overall effect of a potential technology spillover crucially depends on the nature of competition. With quantity competition a technology spillover results in fewer acquisitions. With price competition and horizontally differentiated products a spillover has exactly the opposite effect. Theses contrary effects are caused by the fact that products are either strategic substitutes or strategic complements under the two forms of competition.

Previous work emphasized that asymmetric information may be a hindrance to the formation of mergers. In contrast, our approach analyzes its effects on both alternative modes of foreign entry. For the two scenarios of asymmetric information we also find that this has a negative effect on the overall acquisition activity. The reason for this is that the multinational enterprise sometimes must forgo or forgoes otherwise efficient acquisitions. Furthermore, this result is independent of the nature of competition. Even though the overall effect is unambiguous, we find that under certain conditions private information for MNE results in acquisitions which would not have taken place under full information.

Finally, we proved that the domestic firm is always better off when being privately informed. Interestingly, however, the multinational firm would ex ante prefer full information rather than private information about the potential for a spillover. With private information the MNE sometimes must forgo efficient acquisitions and also sometimes chooses inefficient acquisitions.

The results of our theoretical model are consistent with empirical evidence on foreign market entry. R&D intensive firms rather prefer to enter a foreign market via greenfield investment (Caves and Mehra [1986], Meyer [1998]). Moreover, investors with weak competitive advantages use acquisitions, while investors with strong advantages find greenfield investment to be the more efficient entry mode.[23] Our theoretical results confirm that acquisition should

[23]See Hennart and Park [1993] and Andersson and Svensson [1994].

be the prefered mode of entry if the technology difference is not too large and otherwise greenfield investment is more efficient. Spillovers may only occur if there exists a certain technology gap. However, there is evidence that spillovers are more likely generated if the technology gap is not too large (Xu [2000]).[24] In our model, a spillover can occur (if at all) only in case of greenfield investment. Greenfield investment takes place either under certain conditions for an intermediate technology difference or if the multinational firm possesses a very superior technology. For an intermediate technological difference our results exactly indicate that greenfield investment is chosen whenever the probability of a spillover is sufficiently high. This in turn can lead to a technology spillover. Concerning the case of a very superior technology, we would argue that whether in reality a spillover occurs again depends very much on the absorptive capacity of the domestic firm. Of course in our model this has no effect on the entry mode choice since for a large technology gap the MNE always prefers greenfield investment.

An extension of the model could include the analysis of the choice of entry mode when there are more potential targets for acquisition in the market. In this case it is well known that the scope for a profitable merger is limited.[25] Moreover, it then would be necessary to determine exactly under which circumstances a spillover occurs and whether it benefits all companies in the respective market. These and other considerations are left for future research.

[24]The stock of human capital limits the absorptive capacity of a developing country, as already emphasized in Nelson and Phelps [1966] and empirically tested by Benhabib and Spiegel [1994].

[25]See, for example, Salant, Switzer and Reynolds [1983], Levin [1990], Kamien and Zang [1990] or Gilbert and Newbery [1992] for theoretical discussions.

Appendix

A) The effect of a technology spillover on the greenfield profit and on the acquisition price

Lemma 3 *With quantity competition a technology spillover, i.e. a decrease in c_1, always results in a decrease in π_2, while P_A increases.*

Proof:

With asymmetric costs the greenfield profit for the MNE and the acquisition price are

$$\pi_2 = \frac{(a - 2c_2 + c_1)^2}{9}; P_A = \frac{(a - 2c_1 + c_2)^2}{9}.$$

Differentiating π_2 and P_A with respect to c_1 we get

$$\frac{d\pi_2}{dc_1} = \frac{2(a - 2c_2 + c_1)}{9} > 0,$$

$$\frac{dP_A}{dc_1} = -\frac{4(a - 2c_1 + c_2)}{9} < 0,$$

since by assumption $a > 2c_1 - c_2$. Moreover,

$$\left|\frac{d\pi_2}{dc_1}\right| \gtreqless \left|\frac{dP_A}{dc_1}\right| \Leftrightarrow 5c_1 - 4c_2 \gtreqless a.$$

Therefore, the effect of a marginal reduction in c_1, i.e. a technology spillover, on the greenfield profit of MNE dominates only if the difference in technologies is sufficiently large.

Q.E.D.

Lemma 4 *With price competition and horizontally differentiated products a technology spillover, i.e. a decrease in c_1, always results in a decrease in π_2, while P_A (weakly) increases.*

Proof:

Consider a standard model of horizontal product differentiation with firms competing in prices. Consumers are assumed to be uniformly distributed along the unit interval [0,1] with density 1. HC is located at $x = 0$ and MNE can choose between acquisition of HC or a greenfield investment with $k = 0$ in location $x = 1$. Consumers receive the surplus s from consumption but they have to incur a transportation cost t which is linear in the distance to the firm from which the good is bought. Depending on market characteristics there are three situations that have to be considered.[26] The profit for the multinational firm and the acquisition price in these three cases are:

Case 1: If $t < \frac{c_1 - c_2}{3}$, MNE can force its competitor out of the market by a greenfield investment:

$$\pi_2 = c_1 - c_2 - t; \; P_A = 0.$$

Case 2: If $t \geq \frac{c_1 - c_2}{3}$ and $s \geq \frac{1}{2}(c_1 + c_2 + 3t)$, there exists a marginal consumer with location $\tilde{x}$ who is indifferent between buying from HC or MNE:

$$\pi_2 = \frac{(c_1 - c_2 + 3t)^2}{18t}; \; P_A = \frac{(c_2 - c_1 + 3t)^2}{18t}.$$

Case 3: Both firms have local monopoly power over their consumers. Here, two more situations have to be considered:
(a) If $t \geq \frac{c_1 - c_2}{3}$ and $\frac{1}{2}(c_1 + c_2 + 3t) > s > \frac{1}{3}(2c_1 + c_2 + 3t)$, prices are chosen such that the marginal consumer at $\tilde{x}$ is indifferent between the firms and between buying or not:

$$\pi_2 = \left(\frac{6s - c_1 - 5c_2 - 3t}{6}\right)\left(\frac{c_1 - c_2 + 3t}{6t}\right);$$

$$P_A = \left(\frac{6s - 5c_1 - c_2 - 3t}{6}\right)\left(\frac{c_2 - c_1 + 3t}{6t}\right).$$

(b) If $t \geq \frac{c_1 - c_2}{3}$ and $\frac{1}{3}(2c_1 + c_2 + 3t) \geq s$, HC chooses its monopoly price and MNE sets a price such that there exists a consumer who is indifferent

[26] See Müller [2001] for a detailed analysis.

between the firms and between buying or not:

$$\pi_2 = \left(\frac{3s - c_1 - 2c_2 - 2t}{2}\right)\left(\frac{2t + c_1 - s}{2t}\right);\ P_A = \frac{(s - c_1)^2}{4t}.$$

Differentiating π_2 and P_A with respect to c_1 in the different cases we get:

Case 1: $\frac{d\pi_2^G}{dc_1} = 1,\ \frac{dP_A}{dc_1} = 0.$

Case 2: $\frac{d\pi_2^G}{dc_1} = \frac{c_1 - c_2 + 3t}{9t} > 0,\ \frac{dP_A}{dc_1} = \frac{c_1 - c_2 - 3t}{9t} \leq 0.$

Case 3: (a) $\frac{d\pi_2^G}{dc_1} = \frac{3s - c_1 - 2c_2 - 3t}{18t} > 0,\ \frac{dP_A}{dc_1} = \frac{5c_1 - 2c_2 - 6t - 3s}{18t} < 0.$

(b) $\frac{d\pi_2^G}{dc_1} = \frac{2s - c_1 - c_2 - 2t}{2t} > 0,\ \frac{dP_A}{dc_1} = -\frac{s - c_1}{2t} < 0.$

Moreover, it is easy to see that in *Case 1*, *Case 2* and *Case 3* (b) we have

$$\left|\frac{d\pi_2}{dc_1}\right| > \left|\frac{dP_A}{dc_1}\right|,$$

while in *Case 3* (a)

$$\left|\tfrac{d\pi_2}{dc_1}\right| \geq \left|\tfrac{dP_A}{dc_1}\right|, \text{ for } \tfrac{c_1 - c_2}{3} \leq t \leq \tfrac{4(c_1 - c_2)}{9}, \text{ and}$$

$$\left|\tfrac{d\pi_2}{dc_1}\right| < \left|\tfrac{dP_A}{dc_1}\right|, \text{ for } t > \tfrac{4(c_1 - c_2)}{9}.$$

Therefore, the effect of a marginal reduction in c_1, i.e. a technology spillover, on the greenfield profit of MNE always dominates except under certain conditions for *Case 3* (a).

Q.E.D.

B) Proofs

Proof of Proposition 1:

We simply have to show that with quantity competition condition (2) is more restrictive than condition (1). The monopoly profit with technology $\bar{c}_1$ is given by

$$\pi_1^M = \frac{(a - \bar{c}_1)^2}{4}.$$

The greenfield profits for both parties if or if not a spillover occurs, respectively, are given by

$$\underline{\pi}_1 = \frac{(a - 2\underline{c}_1 + c_2)^2}{9};\ \underline{\pi}_2 = \frac{(a - 2c_2 + \underline{c}_1)^2}{9};$$

$$\bar{\pi}_1 = \frac{(a - 2\bar{c}_1 + c_2)^2}{9};\ \bar{\pi}_2 = \frac{(a - 2c_2 + \bar{c}_1)^2}{9}.$$

Thus, condition (1) becomes

$$\frac{(a - \bar{c}_1)^2}{4} \geq \frac{(a - 2\bar{c}_1 + c_2)^2}{9} + \frac{(a - 2c_2 + \bar{c}_1)^2}{9}.$$

$$\Leftrightarrow a \geq 5\bar{c}_1 - 4c_2 \pm \sqrt{(\bar{c}_1 - c_2)^2}$$

$$\Rightarrow a \geq 11\bar{c}_1 - 10c_2. \tag{1'}$$

(The other solution can be neglected since by assumption $a \geq 2\bar{c}_1 - c_2$.)

Condition (2) becomes

$$\frac{(a - \bar{c}_1)^2}{4} \geq \frac{(a - 2\underline{c}_1 + c_2)^2}{9} + \frac{(a - 2c_2 + \underline{c}_1)^2}{9}$$

$$\Leftrightarrow a \geq 9\bar{c}_1 - 4c_2 - 4\underline{c}_1 \pm 6\sqrt{c_2^2 - 2\bar{c}_1 c_2 + 2\bar{c}_1^2 - 2\bar{c}_1\underline{c}_1 + \underline{c}_1^2}.$$

$$\Rightarrow a \geq 9\bar{c}_1 - 4c_2 - 4\underline{c}_1 + 6\sqrt{(\bar{c}_1 - c_2)^2 + (\bar{c}_1 - \underline{c}_1)^2}. \tag{2'}$$

(The other solution again can be neglected).
Define $\Delta = \bar{c}_1 - \underline{c}_1 > 0$. Where Δ is the potential spillover.
Condition (2′) is more restrictive than condition (1′) if

$$9\bar{c}_1 - 4c_2 - 4\underline{c}_1 + 6\sqrt{c_2^2 - 2\bar{c}_1 c_2 + 2\bar{c}_1^2 - 2\bar{c}_1\underline{c}_1 + \underline{c}_1^2} > 11\bar{c}_1 - 10c_2$$

$$\Leftrightarrow 17\bar{c}_1^2 - 12\bar{c}_1 c_2 - 22\bar{c}_1\underline{c}_1 + 5\underline{c}_1^2 + 12\underline{c}_1 c_2 > 0$$

$$\Leftrightarrow 12\bar{c}_1 - 12c_2 + 5\Delta > 0.$$

The final inequality holds since $\bar{c}_1 > c_2$ and $\Delta > 0$.

Q.E.D.

Proof of Proposition 2:

We have to show that with price competition and horizontally differentiated products condition (1) is more restrictive than condition (2). The monopoly profit with technology $\bar{c}_1$ is

$$\pi_1^M = \begin{cases} s - t - \bar{c}_1 & \text{, if } s \geq \bar{c}_1 + 2t, \\ \frac{(s-\bar{c}_1)^2}{4t} & \text{, otherwise.} \end{cases}$$

Acquisition is the optimal mode of entry if the respective monopoly profit exceeds the sum of the greenfield profit for MNE and of the acquisition price, which is reflected in conditions (1) and (2). By Proof of Lemma 4 we already know that the effect of a marginal reduction in c_1 on the greenfield profit for MNE dominates the effect on the acquisition price in all cases except under certain conditions for *Case 3* (a). Therefore, it is obvious that in all these other cases a spillover results in acquisition becoming relatively more attractive, or, in other words, condition (1) being more restrictive than (2). The greenfield profits for both parties in *Case 3* (a) if no spillover occurs are given by

$$\bar{\pi}_1 = \left(\frac{6s - 5\bar{c}_1 - c_2 - 3t}{6}\right)\left(\frac{c_2 - \bar{c}_1 + 3t}{6t}\right);$$

$$\bar{\pi}_2 = \left(\frac{6s - \bar{c}_1 - 5c_2 - 3t}{6}\right)\left(\frac{\bar{c}_1 - c_2 + 3t}{6t}\right).$$

Thus, condition (1) becomes

$$\begin{aligned} \tfrac{(s-\bar{c}_1)^2}{4t} \quad &\geq \quad \left(\tfrac{6s-5\bar{c}_1-c_2-3t}{6}\right)\left(\tfrac{c_2-\bar{c}_1+3t}{6t}\right) + \left(\tfrac{6s-\bar{c}_1-5c_2-3t}{6}\right)\left(\tfrac{\bar{c}_1-c_2+3t}{6t}\right) \\ &\Leftrightarrow s \leq \bar{c}_1 + 2t \pm 2\sqrt{\frac{1}{9}(\bar{c}_1 - c_2)^2 + \frac{1}{2}t(\bar{c}_1 - c_2 + t)} \\ &\Rightarrow s \leq \bar{c}_1 + 2t - 2\sqrt{\frac{1}{9}(\bar{c}_1 - c_2)^2 + \frac{1}{2}t(\bar{c}_1 - c_2 + t)}. \qquad (1'') \end{aligned}$$

(The other solution can be neglected since in *Case 3* we have $s < \bar{c}_1 + 2t$.) However, condition $(1'')$ can never be fulfilled because in *Case 3* (a) we must have $s > \frac{1}{3}(2\bar{c}_1 + c_2 + 3t)$:

$$\frac{1}{3}(2\bar{c}_1 + c_2 + 3t) > \bar{c}_1 + 2t - 2\sqrt{\frac{1}{9}(\bar{c}_1 - c_2)^2 + \frac{1}{2}t(\bar{c}_1 - c_2 + t)}$$

$$\Leftrightarrow 9t^2 + 12t\bar{c}_1 - 12tc_2 > -3(\bar{c}_1 - c_2)^2.$$

The final inequality holds since $\bar{c}_1 > c_2$.
Thus, in other words, without a spillover greenfield investment is always the optimal entry mode in *Case 3* (a). If, on the other hand, a spillover occurs this will at least not result in fewer acquisitions independently of whether condition (2) can be fulfilled in *Case 3* (a). Note finally that in *Case 3* (b) acquisition will never take place anyway.

Q.E.D.

Proof of Lemma 1:

In equilibrium MNE will obviously never offer $P_A > \underline{\pi}_1$ since the domestic firm accepts $P_A = \underline{\pi}_1$ anyway. We can also ignore any offer $0 < P_A < \bar{\pi}_1$ which will always be rejected by the domestic firm and it is payoff equivalent to an offer $P_A = 0$. Moreover, any offer $\bar{\pi}_1 < P_A < \underline{\pi}_1$ cannot be an equilibrium offer since this would only be accepted if no spillover occurs which can also be achieved by offering $P_A = \bar{\pi}_1$. Therefore, the multinational firm will offer $P_A = \underline{\pi}_1$ or $P_A = \bar{\pi}_1$ or $P_A = 0$ depending on the efficiency of acquisition and on the probability of a spillover.
If (2) is met, acquisition is efficient independently of a spillover. The multinational prefers to offer $P_A = \underline{\pi}_1$ instead of $P_A = \bar{\pi}_1$ if the probability of a spillover q is high enough such that the gain from becoming a monopolist outweighs the loss of a too high offer in case no spillover would have occured:

$$\pi_1^M - \underline{\pi}_1 \geq q\underline{\pi}_2 + (1-q)[\pi_1^M - \bar{\pi}_1]$$

$$\Leftrightarrow q \geq \frac{\underline{\pi}_1 - \bar{\pi}_1}{\pi_1^M - \bar{\pi}_1 - \underline{\pi}_2} = \hat{q}.$$

Where $\hat{q} \in (0,1)$ since $\underline{\pi}_1 > \bar{\pi}_1$ and by (2).
If only condition (1) is fulfilled acquisition at price $P_A = \bar{\pi}_1$ is efficient and will be accepted only if there is no potential for a spillover. Otherwise this offer is rejected. If acquisition is never efficient $P_A = 0$ is chosen.

Q.E.D.

Proof of Lemma 2:

There are three types of possible equilibrium acquisition offers P_A which can be supported by different sets of beliefs for different parameter constellations:

1. A pooling equilibrium in which the MNE makes an offer which is always accepted.

2. A separating equilibrium in which MNE makes an offer only if there is potential for a spillover. This offer is accepted. Otherwise MNE makes no offer.

3. A pooling equilibrium in which MNE never makes an offer independently of its type.

Pooling equilibrium *1.*: Consider an acquisition offer with $P_A = E[\pi_1]$, where $E[\pi_1] = q\underline{\pi}_1 + (1-q)\bar{\pi}_1$ and suppose that each type of MNE makes such an offer. According to Baye's rule the updated belief of HC is then $\tilde{q} = q$, i.e. HC does not learn anything. For the out-of-equilibrium belief Baye's Rule cannot be applied and HC is free to believe anything. However, updating has to be consistent with the equilibrium strategies. The proposed equilibrium acquisition offer can be supported by an out-of-equilibrium belief $\tilde{q} = 1$. Such an equilibrium exists if both types of MNE, i.e. with or without potential for a spillover, gain from such an offer:

$$\pi_1^M - E[\pi_1] \geq \bar{\pi}_2$$

$$\Leftrightarrow \pi_1^M \geq E[\pi_1] + \bar{\pi}_2. \tag{3}$$

Separating equilibrium *2.*: The MNE with potential for a spillover makes a high offer $P_A = \underline{\pi}_1$, while the other type makes no offer. Thus, HC can always update its beliefs according to Baye's Rule. Therefore, if $P_A = \underline{\pi}_1$ is observed, the updated belief becomes $\tilde{q} = 1$ and otherwise $\tilde{q} = 0$. The proposed equilibrium exists if condition (2) is fulfilled and if it's not worthwhile for the type of MNE without potential for a spillover to imitate, i.e. if

$$\pi_1^M - \underline{\pi}_1 < \bar{\pi}_2$$

$$\Leftrightarrow \bar{\pi}_2 + \underline{\pi}_1 > \pi_1^M. \tag{4}$$

Obviously, conditions (4) and (2) can be simultaneously fulfilled since $\bar{\pi}_2 > \underline{\pi}_2$.

Finally, pooling equilibrium *3.* with $P_A = 0$ exists if condition (2) is not fulfilled. In this case it is not efficient for a MNE with potential for a spillover to acquire. The type of MNE without a potential for a spillover is not able to separate since any positive offer could be profitably replicated by the other type of MNE.

The proposed equilibria can exist at the same time. For certain parameter constellations the pooling equilibrium *1.* and the separating equilibrium *2.* or both pooling equilibria exist simultaneously. More precisely, conditions (3) and (4) can be fulfilled at the same time and therefore equilibrium *1.* and *2.* exist simultaneously if

$$\pi_1^M - E[\pi_1] \geq \bar{\pi}_2 \geq \pi_1^M - \underline{\pi}_1.$$

Both pooling equilibria may coexist since (3) can be fulfilled and at the same time (2) can be violated if

$$\pi_1^M - E[\pi_1] \geq \bar{\pi}_2 > \underline{\pi}_2 > \pi_1^M - \underline{\pi}_1.$$

In short, coexistence is only given if (3) or (4) are fulfilled. Otherwise all proposed equilibria exist independently of each other. Finally, the separating equilibrium *2.* and the pooling equilibrium *3.* are obviously mutually exclusive by (2).

Q.E.D.

Proof of Proposition 3:

By Lemma 1 with private information for HC acquisition is chosen whenever it is also efficient with full information except for the case where (2) is fulfilled and $q < \hat{q}$. In this case, if there is potential for a spillover, greenfield investment takes place even though acquisition would have been efficient.

Q.E.D.

Proof of Proposition 4:

HC can gain only if MNE offers more than the actual post greenfield profit for HC. This happens if (2) is fulfilled and $q \geq \hat{q}$, but there is no potential for a spillover. In this case MNE makes a high offer, $P_A = \underline{\pi}_1$, if HC is privately informed, while MNE would make a low offer, $P_A = \bar{\pi}$, with full information. Condition (2) is fulfilled if the technology difference and/or the potential spillover, i.e. $\bar{c}_1 - c_2$ and/or $\Delta = \bar{c}_1 - \underline{c}_1$, are not too large as inspection of condition $(2')$ in proof of Proposition 1 displays. In all other situations HC receives the same payoff with private information as with full information.

Q.E.D.

Proof of Proposition 5:

MNE suffers form private information if either the domestic firm is acquired too expensive or acquisition inefficiently not takes place. This can happen only if (2) is fulfilled. In this case if $q \geq \hat{q}$ MNE offers too much if there is no potential for a spillover or if $q < \hat{q}$ MNE offers too little and thus acquisition not takes place if a spillover actually occurs. In all other situations MNE receives the same payoff with private information as with full information.

Q.E.D.

Proof of Proposition 6:

With full information if condition (1) is met but (2) is not fulfilled and a spillover occurs, MNE chooses greenfield investment since acquisition at price $P_A = \underline{\pi}_1$ is too expensive relative to the monopoly profit. If no spillover occurs MNE acquires the domestic firm at price $P_A = \bar{\pi}_1$. With private information for MNE the acquisition price in pooling equilibrium *1.* becomes $P_A = E[\pi_1]$ and this is always accepted. Therefore, the acquisition price is low enough for acquisition to be profitable even if there is potential for a spillover. Since for certain parameter constellations the pooling equilibrium *1.* exists, if (3) is fulfilled and simultaneously (2) violated, private information for MNE may thus lead to more acquisitions than full information.

Q.E.D.

Proof of Proposition 7:

By Lemma 2 with private information for MNE, if condition (1) is met, in separating equilibrium *2.* or pooling equilibrium *3.* acquisition inefficiently does not take place if there is no potential for a spillover. Therefore, private information has a negative effect on the acquisition activity. However, by Proposition 6 pooling equilibrium *1.* leads under certain conditions to more acquisitions than full information. But overall this positive effect on the acquisition activity is more than offset by the two negative effects.
More formally, pooling equilibrium *1.* results in acquisitions which would not have taken place under full information within the parameter space in which conditions (1) and (3) are met and condition (2) is violated. Separating equilibrium *2.* and pooling equilibrium *3.* may result in greenfield investment, while for full information acquisition would have taken place within the parameter space in which condition (3) is not fulfilled but conditions (1) and (4) are met. Since conditions (2) and (3) cross for some value of $q \in (0, 1)$ the former parameter space must be more restricted than the latter.[27]

Q.E.D.

Proof of Proposition 8:

From the view of HC in pooling equilibrium *1.* the acquisition price $P_A = E[\pi_1]$ is too small compared to the acceptable offer under full information if there is potential for a spillover and it is too large otherwise. Therefore, HC suffers from private information for MNE in the former case, while it gains in the latter. In all other situations HC receives a payoff which is equivalent to its post greenfield profit independently of whether acquisition or greenfield investment is chosen.

Q.E.D.

[27]See Figure 1 for a graphical illustration. In Figure 1 the parameter space for which pooling equilibrium *1.* results in more acquisitions is represented by the triangle between the lines (2) and (3) and $q = 0$. The other situation is represented by the triangle between the lines (1) and (3) and $q = 1$. Note that the former space is always more restricted than the latter independently of the exact relation between conditions (1), (2), (3) and (4).

Proof of Proposition 9:

MNE gains from having private information only in pooling equilibrium if there is potential for a spillover. In this situation the acquisition price $P_A = E[\pi_1]$ is smaller than it would be with full information. The multinational cannot take advantage of its private information in any other situation. On the other hand, MNE acquires HC at a too high price in pooling equilibrium *1.* if no spillover would have occured. Moreover, MNE also suffers from being privately informed if condition (1) is fulfilled and a spillover does not occur. In this case with full information acquisition would have been efficient but greenfield investment is chosen if MNE is privately informed.

Q.E.D.

Proof of Proposition 10:

First, we derive the expected payoffs for MNE for the different informational scenarios.

1. Full Information:

$$E[\pi_1] = q\underline{\pi}_1 + (1-q)\bar{\pi}_1.$$

(a) $E[\pi_2] = \pi_1^M - E[\pi_1]$, if conditions (1) and (2) are fulfilled.

(b) $E[\pi_2] = q\underline{\pi}_2 + (1-q)[\pi_1^M - \bar{\pi}_1]$, if only condition (1) is fulfilled.

(c) $E[\pi_2] = q\underline{\pi}_2 + (1-q)\bar{\pi}_2$, if none of the conditions is fulfilled.

2. Private Information for HC:

(a) $E[\pi_2|q \geq \hat{q}] = \pi_1^M - \underline{\pi}_1$ or

$E[\pi_2|q < \hat{q}] = q\underline{\pi}_2 + (1-q)[\pi_1^M - \bar{\pi}_1]$, if conditions (1) and (2) are fulfilled.

(b) $E[\pi_2] = q\underline{\pi}_2 + (1-q)[\pi_1^M - \bar{\pi}_1]$, if only condition (1) is fulfilled.

(c) $E[\pi_2] = q\underline{\pi}_2 + (1-q)\bar{\pi}_2$, if none of the conditions is fulfilled.

3. Private Information for MNE:

$$E[\pi_1] = q\underline{\pi}_1 + (1-q)\bar{\pi}_1.$$

(*a*) $E[\pi_2] = \pi_1^M - E[\pi_1]$, if (3) is fulfilled.

(*b*) $E[\pi_2] = q[\pi_1^M - \underline{\pi}_1] + (1-q)\bar{\pi}_2$, if conditions (2) and (4) are fulfilled.

(*c*) $E[\pi_2] = q\underline{\pi}_2 + (1-q)\bar{\pi}_2$, if (2) is not fulfilled.

Comparison of the different expected profits for MNE shows that the full information expected profit always weakly dominates the expected profit with asymmetric information. More precisely, expected profits when HC has private information are equal to the full information case except in (a) where the expected profit with full information is higher:

1. $\pi_1^M - E[\pi_1] > \pi_1^M - \underline{\pi}_1$, which obviously is fulfilled.

2. $\pi_1^M - E[\pi_1] > q\underline{\pi}_2 + (1-q)[\pi_1^M - \bar{\pi}_1] \Leftrightarrow \pi_1^M > \underline{\pi}_1 + \underline{\pi}_2$, which is fulfilled by (2).

Now we compare expected profits with full information and with private information for MNE. Pooling equilibrium *1.* and full information yield the same expected profit if (2) is met. Otherwise if (2) is not fulfilled the expected profit with full information is higher:

$$q\underline{\pi}_2 + (1-q)[\pi_1^M - \bar{\pi}_1] > \pi_1^M - E[\pi_1] \Leftrightarrow \underline{\pi}_1 + \underline{\pi}_2 > \pi_1^M.$$

Separating equilibrium *2.* always yields a lower expected payoff than the full information expected payoff:

$\pi_1^M - E[\pi_1] > q[\pi_1^M - \underline{\pi}_1] + (1-q)\bar{\pi}_2 \Leftrightarrow \pi_1^M > \bar{\pi}_1 + \bar{\pi}_2$, which is fulfilled by (2).

Finally, pooling equilibrium *3.* yields the same expected payoff as with full information if (1) is violated. Otherwise if (1) is fulfilled the full information expected payoff is larger:

$$q\underline{\pi}_2 + (1-q)[\pi_1^M - \bar{\pi}_1] > q\underline{\pi}_2 + (1-q)\bar{\pi}_2 \Leftrightarrow \pi_1^M > \bar{\pi}_1 + \bar{\pi}_2.$$

Q.E.D.

Proof of Proposition 11:

HC's expected payoff is equal to

$$E[\pi_1] = q\underline{\pi}_1 + (1-q)\bar{\pi}_1$$

except for the case of private information for HC and condition (1) fulfilled. In this case if (1) is met the expected payoff is

$$E[\pi_1|q \geq \hat{q}] = \underline{\pi}_1, \text{ or}$$

$$E[\pi_1|q < \hat{q}] = q\underline{\pi}_1 + (1-q)\bar{\pi}_1.$$

Thus, HC always receives the same expected payoff with the above exception in all cases. Since for $q \geq \hat{q}$ the expected payoff is larger, HC (weakly) prefers private information.

Q.E.D.

Relative relation between conditions (1) - (4):

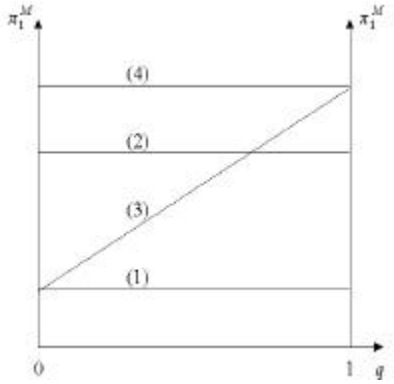

Figure 1: Relation of conditions (1) - (4) under quantity competition.

C) Asymmetric information and price competition

We will now show that the effects of asymmetric information about a potential technology spillover on the entry mode remain qualitatively the same for the case of price competition with horizontally differentiated products. Hence, asymmetric information reduces the parameter space for which acquisition is the optimal entry mode. The main difference is that condition (1) is more restrictive than (2), as already shown in Proposition 2.

The effects of asymmetric information differ with respect to the equilibrium acquisition offer, if the domestic firm has private information about potential technology spillovers:

Lemma 5 *The equilibrium acquisition offer is*

(a) $P_A = \underline{\pi}_1$ *if condition (1) is fulfilled and* $q \geq \hat{q}$,
or if only condition (2) is fulfilled and $q \geq \tilde{q}$,

(b) $P_A = \bar{\pi}_1$ *if condition (1) is fulfilled and* $q < \hat{q}$,

(c) $P_A = 0$ *otherwise,*

where $\hat{q} = \frac{\underline{\pi}_1 - \bar{\pi}_2}{\pi_1^M - \bar{\pi}_1 - \underline{\pi}_2}$ *and* $\tilde{q} = \frac{\underline{\pi}_1 + \bar{\pi}_2 - \pi_1^M}{\bar{\pi}_2 - \underline{\pi}_2}$.

Proof:

As argued in proof of Lemma 1, MNE will offer $P_A = \underline{\pi}_1$, $P_A = \bar{\pi}_1$ or $P_A = 0$ depending on the efficiency of acquisition and on the probability of a spillover. If (1) is met, acquisition is efficient independently of a spillover. MNE prefers to offer $P_A = \underline{\pi}_1$ instead of $P_A = \bar{\pi}_1$, if the probability of a spillover q is high enough such that the gain from becoming a monopolist outweighs the loss of a too high offer in case there is no potential for a spillover:

$$\pi_1^M - \underline{\pi}_1 \geq q\underline{\pi}_2 + (1-q)[\pi_1^M - \bar{\pi}_1]$$

$$\Leftrightarrow q \geq \frac{\underline{\pi}_1 - \bar{\pi}_1}{\pi_1^M - \bar{\pi}_1 - \underline{\pi}_2} = \hat{q}.$$

Where $\hat{q} \in (0,1)$ since $\underline{\pi}_1 > \bar{\pi}_1$ and by (2). Otherwise MNE offers $P_A = \bar{\pi}_1$.

If only condition (2) is fulfilled acquisition is efficient only if there is potential for a spillover. MNE prefers to offer $P_A = \underline{\pi}_1$ instead of no offer, $P_A = 0$, if the probability of a spillover q is high enough:

$$\pi_1^M - \underline{\pi}_1 \geq q\underline{\pi}_2 + (1-q)\bar{\pi}_2$$

$$\Leftrightarrow q \geq \frac{\underline{\pi}_1 + \bar{\pi}_2 - \pi_1^M}{\bar{\pi}_2 - \underline{\pi}_2} = \tilde{q}.$$

Where $\tilde{q} \in (0,1)$ since: 1. $\underline{\pi}_1 + \bar{\pi}_2 > \bar{\pi}_1 + \bar{\pi}_2 > \pi_1^M$, because (1) is not fulfilled.
2. $\bar{\pi}_2 - \underline{\pi}_2 > \underline{\pi}_1 + \bar{\pi}_2 - \pi_1^M \Leftrightarrow \pi_1^M > \underline{\pi}_1 + \underline{\pi}_2$ by (2).
Otherwise acquisition is not efficient and hence $P_A = 0$ is chosen.

Q.E.D.

Lemma 5 shows that Proposition 3 is valid also with price competition. Asymmetric information reduces the parameter space for which acquisition is the optimal entry mode. The reason for this is the following. With private information for MNE greenfield investment is chosen, while acquisition is efficient with full information, if:
1. (1) is fulfilled and $q < \hat{q}$.
2. only (2) is fulfilled and $q < \tilde{q}$ and a spillover occurs.
On the other hand, if (2) is fulfilled and $q \geq \tilde{q}$ but there is no potential for a spillover, MNE chooses acquisition even though under full information greenfield investment would have taken place. However, overall this positive effect on the acquisition activity is more than offset by the two negative effects.

If MNE has private information about potential technology spillovers Lemma 2 still applies. Moreover, Proposition 7 remains also unchanged. In contrast to quantity competition condition (1) is more restrictive than (2). As a consequence, there cannot exist parameter constellations where under private information for MNE acquisition takes place even though with full information MNE would have chosen greenfield investment. However, there are cases where MNE makes no acquisition offer even though this would have been efficient under full information, i.e. in separating equilibrium *2.* Thus, private information for MNE reduces the parameter space for which acquisition is the optimal mode of entry. Figure 2 gives a graphical illustration of

conditions (1) - (4) under price competition:

Relative relation between conditions (1) - (4):

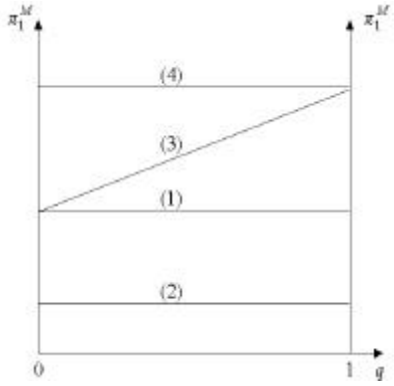

Figure 2: Relation of conditions (1) - (4) under price competition with horizontally differentiated products.

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