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Modeling Foreign direct investment by a Prisoner's dilemma: Greenfield investment (cooperation) or Mergers and Acquisitions (defection)

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Abstract. Foreign direct investment (FDI) is a heterogeneous flow of funds, composed of both acquisition (cross-border mergers and acquisitions, M&A) and Greenfield investment (GF). Since the dilemma of a firm between GF and M&A is similar to the one between cooperation and defection in Prisoner's Dilemma (PD), we used PD for modeling FDI. We discuss the conditions for the firms to take GF (cooperation) option by equilibrium analysis

Keywords: Foreign direct investment, Mergers and Acquisitions, Greenfield, Prisoner's dilemma, Equilibrium, Game theory

1. Introduction

In an increasingly globalized world, the decision of how best to invest into foreign markets is becoming one of the key challenges facing international firms. A firm that decides to market its product abroad has two distinct options of investing into foreign markets: either exporting or local production (foreign direct investment, FDI). If the firm decides to produce locally, it can choose between building its own establishment (Greenfield investment, GF) or to acquire an existing local firm (cross-border merger and acquisition, M&A) [1]. In this paper, we model that accession by a Prisoner's dilemma (PD). We developed a general equilibrium model of international trade and investment with heterogeneous firms. In equilibrium, different firms choose different modes of foreign market access as players. The aim of this paper is to derive an "international organization of production" : a mapping from firm type to mode of foreign access. We showed that the international organization of production is fundamentally different from one industry to another, depending on the nature of firm heterogeneity.

FDI is considered as one of the main driving forces behind nowadays wave of globalization. An increase in economic integration can be observed over the last decade. This leads us to the question of whether

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or not economic integration may trigger FDI, and if that is the case, which strategy that international firms should use when investing into new markets [2]. We examine many firm type models, as players' action, to find the best strategy that the firms should use – M&A or GF– by comparing their profitability in each different possibility.

FDI is defined as an investment that involves a long-term relationship and reflects a lasting interest and control by a firm in one country (investor) in an enterprise resident in an economy other than that of the investor. There are different ways a firm can enter a foreign market. We focused on two types of business strategy to conduct FDI: they can either acquire an existing firm in the host country through M&A or they can set up a new venture in another country by choosing GF as an option. The firm's decision may be influenced, among other things, by the entry costs to a foreign market, especially trade and investment costs [3].

Over the last decades, there have been several waves of increased activity in FDI. Each of those waves has its own characteristics. In the 1970s, for example, international firms mainly tried to achieve economies of scale. In the 1980s, the priority was to gain from the synergy effects, especially in the single market of the European Union (EU merger control act). Since mid 1990s, an unprecedented wave of FDI can be observed with its latest peak at the beginning of the 21st century, characterized by deregulated and growing markets from globalization.

In the next sections, this paper is structured as follows. Part 2 presents a brief overview of the FDI in the PD model. First, PD model in general context is introduced. Then, GF vs. M&A in FDI is shown. The application of the model is presented in part 3. We also discussed the conditions for the firms to take GF (cooperation) by equilibrium analysis. Finally, the paper is concluded in part 4.

2. The FDI in the Prisoner's dilemma

2.1. The Prisoner's dilemma

Two individuals are arrested for engaging in a serious crime and are held in separate cells. The police try to extract a confession from each person. Each is privately sentence. If both confess they will get 3 years sentence. If neither confesses they will get 1 year sentence. If one of them confess, he will get free, other person will get 5 years sentence.

PD is a game played once by two players with two available actions: cooperation C, or defect D.

Table 1. The payoff matrix of the PD game

		Player 2	
		C	*D*
Player 1	*C*	**R,R**	**S,T**
	D	**T,S**	**P,P**

If both cooperate, their payoff R (reward) is higher than the payoff P (punishment) obtained if both defect. But if one player defects while the other cooperates, then tie defector's payoff T (temptation) is higher than R, while the cooperator's payoff S (sucker) is smaller than P.

$$T > R > P > S \quad (1)$$

It is furthermore assumed that:

$$2R > T + S \quad (2)$$

Table 2. PD payoffs with T=5, R=3, P=1 and S=0

		Player 2	
		C	*D*
Player 1	*C*	**3,3**	**0,5**
	D	**5,0**	**1,1**

So that joint cooperation is more profitable than alternating C and D.

Player has an action and a strategy. He (and hence the strategy) plays PD with opponent, and changes his action according to the total score that he receive [4]. In the future model, we will propose the strategy determines the next action depending on the result of logical function of the opponent in two last actions.

2.2. Greenfield vs Mergers&Acquisitions in PD

In this model, we try to answer the question when firms should use M&A or GF as a form of entry mode into another country's market. The model demonstrates the synergy effects of increased competition on the profitability of M&A. Further, the effects of entry costs on the firms' profitability are taken into account. This allows conclusions about which form of entry should be preferred.

In recent years, the globalization of firms has assumed two new features. First, firms increasingly enter foreign markets by acquiring a local producer (M&A) instead of opening a new subsidiary (GF). The phenomenon is particularly apparent in industrialized host countries, where the bulk of FDI inflows enter trough M&A. Second, the interaction between the international strategy and the innovative activity of firms has become increasingly rigorous and complex, due to the key role of multinational companies in the process of generation and transfer of technology and knowledge in the global market [5]. Models therefore should take into account for features which nowadays characterize the internationalization process, capturing the technological implications of M&A.

At first, we consider a situation with two firms, firm A and firm B invest together to firm X by any merger activity. In the benchmark case both firms have identical technologies and marginal production costs. Firm X is the target firm, located in country Y, whereas firm A and B are the foreign firms located outside country Y. These two foreign firms consider how to enter country Y's market. In modeling by PD, GF investment count as cooperation (C) and M&A count as defection (D), respectively. Because M&A allows a firm to get costly access to the country-specific capabilities of the acquired firm, and the price of such an M&A is governed by demand and supply of firms in the market for corporate control. In contrast, by engaging in Greenfield FDI, a firm brings only its own capabilities to work abroad. If a firm enters the foreign market through GF, 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 M&A, it must offer the other firm a sufficiently high M&A 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 synergy effects that improve productivity. The payoff matrix of how the foreign firms can enter and afterwards serve the domestic market as the PD model:

Table 3. The payoff matrix of two firms invest to firm X

		Firms 2	
		GF	*M&A*
Firms 1	*GF*	Holding	Absorption
	M&A	Preservation	Symbiosis

Each firm, as a player has two actions, M&A or GF. With payoff Holding, both GF, firms allow little autonomy - yet do not integrate the target into its businesses. With payoff Absorption, one player GF while other M&A, firms completely absorb the target firm. If the target firm is large, this can take time. With payoff Preservation, one player M&A while other GF, firms make very few changes to the target, and instead learned from it in preparation for future growth. Finally, with payoff Symbiosis, both players M&A, they integrate the target in order to achieve synergies - but allows for autonomy, for example to retain and motivate employees. This is possibly the most difficult to implement.

The payoff functions for the players capture the consequences that any given choice of actions has for each player. It is assumed that players have complete information, so that once a pair of actions is chosen, the objective function for each player maps these into a payoff. The actions of the foreign firm can affect domestic firm and themselves, the firm's payoff function in the FDI game takes on this table.

3. Modeling

The payoff of both firms:

Table 4. General payoff matrix of a PD game

		Firm B	
		GF	*M&A*
Firm A	*GF*	R_1,R_2	*S,T*
	M&A	*T,S*	P_1,P_2

In the PD, $R_1=R_2$, they become R. Similarly, $P_1=P_2$, become P:

Table 5. Reduced payoff matrix of a PD game

		Firm B	
		GF	*M&A*
Firm A	*GF*	***R***	***S,T***
	M&A	***T,S***	***P***

The profits of the two firms vary depending on the market configurations. Four possible market configurations may arise:

Table 6. Four possible market configurations of modeling to the PD game

R= (GF, GF)	We have both firms undertake Greenfield FDI
S= (GF, M&A)	Firm A undertakes a Greenfield FDI while firm B *M&A*
T= (M&A, GF)	Firm A undertakes a *M&A* while firm B *GF*
P= (M&A, M&A)	We have both firms undertake *M&A*

Both firms introduce cost saving innovations. We assume that a total knowledge pool is divided between the two choices in proportion k for *M&A* and $(1-k)$ for *GF*

with $k \in [0, 0.5]$. Therefore, knowledge pool cost of *GF* is always greater than *M&A*.

We hold that unit variable of production cost depends on firm's exogenous cost, including technological reduction.. Based on [3], with the unit variable p_A, p_B for firm A and firm B, respectively, the total costs are given by:

$$c_{M\&A} = k + p_A \quad (3)$$

$$c_{GF} = 1 - k + p_B \quad (4)$$

The costs of internal knowledge transfer are inversely proportional to the parameter $t \in [0,1]$. Due to absence of external knowledge transfer, we have:

$$c_{M\&A} = tk + p_A \quad (5)$$

$$c_{GF} = t(1-k) + p_B \quad (6)$$

In addition, a cross border *M&A* has important technological implications which decrease the firm's cost of production. The unit production cost in *M&A* is:

$$c_{M\&A} = tk + p_A + e(k(1-k)) \quad (7)$$

The parameter e is considered synergy effect when a firm makes *M&A*.

If a firm chooses to enter a foreign market through *GF* it faces a fixed cost F as a new production unit should be built:

$$c_{GF} = t(1-k) + p_B + F \quad (8)$$

We call the parameter $w \geq 1$ measures the size of the world market while the parameter $s \in [0, 0.5]$ indicates the share of the world market accounted for *GF* and thus *(1-s)* the share accounted for by *M&A*.

The profits were calculated by sales minus cost. Thus the payoff functions profit for each of these market structures are reported as:

$$R = ws - \left(t(1\text{-}k) + p_B + F\right) \quad (9)$$

$$S = ws - \left(tk + p_A + ek\right) \quad (10)$$

$$T = w(1-s) - \left(t(1\text{-}k) + p_B + F\right) \quad (11)$$

$$P = w(1-s) - \left(tk + p_A + ek\right) \quad (12)$$

Eq. 9 – Eq. 12 to satisfy the condition in the PD in Eq. 1: $T > R > P > S$ and Eq. 2: $2R > T + S$

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 between *GF* and *M&A*. We first find the PD solution of the constrained game with strategy space S= {*GF, M&A*}. Then we solve the acquisition decision by applying the Nash fixed-threat bargaining equilibrium concept.

The equilibrium mode of entry: The PD game with S= {*GF, M&A*}

We shall now discuss how the firms will make their choices, regarding the mode of foreign expansion. Before addressing the *M&A* decision, we should determine the solution of the PD game with strategy space S= {*GF, M&A*}. 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 *GF* and *M&A*, 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 of a matrix game between the two firms where the payoffs are the equilibrium profits of each single firm.

The equilibrium profits for each market configurations, obtained by substituting in equations 9-12 the optimal sales we get by solving the second stage games, based on [3] are:

$$\hat{R} = \frac{(ws - (t(1-k) + p_B))^2}{4} - F \qquad (13)$$

$$\hat{S} = \frac{(ws - (tk + p_A + ek))^2}{9} \qquad (14)$$

$$\hat{T} = \frac{(w(1-s) - (t(1-k) + p_B))^2}{9} - F \qquad (15)$$

$$\hat{P} = \frac{(w(1-s) - (tk + p_A + ek))^2}{9} \qquad (16)$$

By comparing the profit functions under alternative strategy combinations, we can identify the conditions for the firm to take dominant strategies with $\hat{R} > 0$ and $\hat{P} > 0$:

$$\frac{(ws - (t(1-k) + p_B))^2}{4} > F \qquad (17)$$

$$\frac{(w(1-s) - (tk + p_B + ek))^2}{9} > 0 \qquad (18)$$

The Eq. 17 takes from Eq. 13. If Eq. 17 holds, *M&A* is the dominant strategy for firm A. Otherwise, *GF* will be the dominant strategy. Similarly, The Eq. 18 takes from Eq. 16. If Eq. 18 holds, *M&A* will be the dominant strategy for firm B.

As to the effect of relative market size (captured by the parameter *s*), the probability that Eq. 17 (Eq. 18) holds and thus that firm A (firm B) establishes a new subsidiary abroad is decreasing (increasing) in *s*:

$$\frac{\partial LHS(17)}{\partial s} = \frac{2w(ws - (t(1-k) + p_B))}{4} > 0 \qquad (19)$$

$$\frac{\partial LHS(18)}{\partial s} = -\frac{2w(w(1-s) - (tk + p_A + ek))}{9} < 0 \qquad (20)$$

This finding reminds us that a large host market is an important attractor for inward FDI since it will imply higher variable profits, making it easier to compensate for the additional fixed plant costs associated to a *GF*. Synergy effects is more powerful the larger the size of the overall market (that is the higher the parameter *w)*.

Eq. 19 and Eq. 20 can be rearranged respectively as:

$$s > \frac{2}{w^2} + \frac{t + p_B}{w} - \frac{t}{w}k \qquad (23)$$

$$s < 1 - \frac{9}{2w^2} + \frac{p_A}{w} - \frac{t - e}{w}k \qquad (24)$$

Fig 1 and Fig 2 illustrates how the equilibrium strategy choice depends on the value of s and t, where the size of the world market (w) is set to 3 in Fig 1 and 5 in Fig 2 respectively.

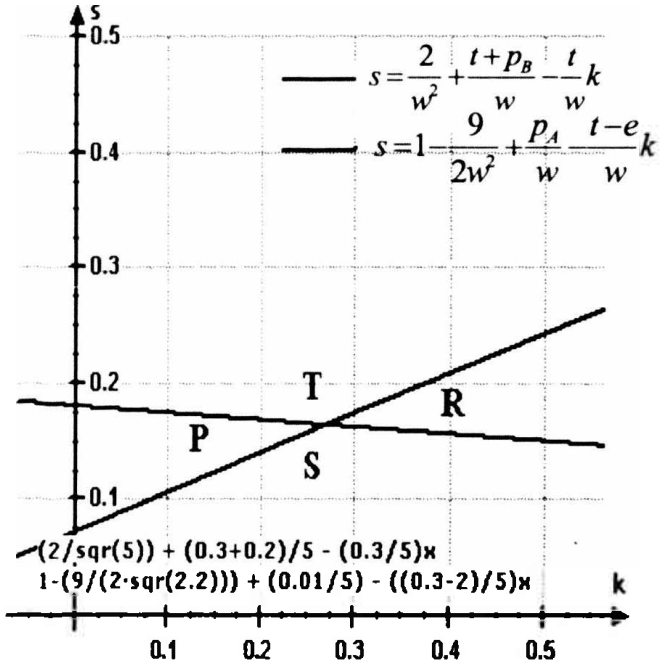

Fig. 1. Regions defining equilibrium outcomes in the *(s,k)* plan with t=0.3; p_A=0.01; p_B=0.2; e=2; and w=5 in Eq. 23

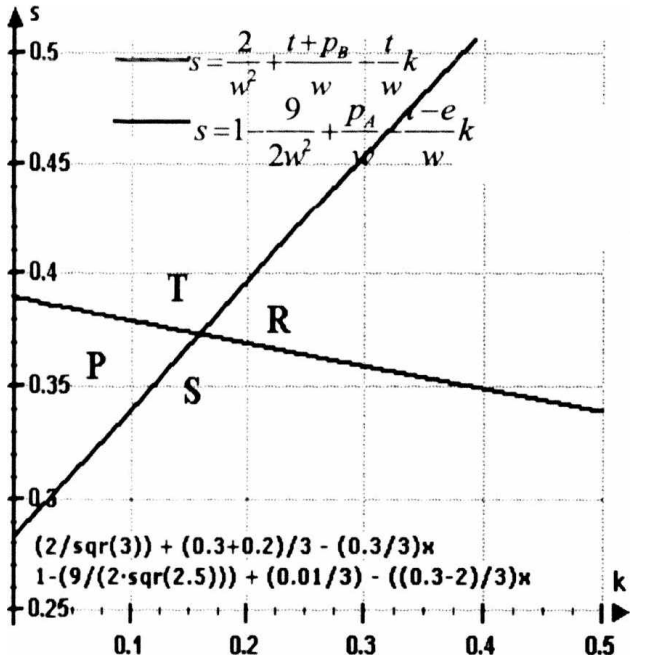

Fig. 2. Regions defining equilibrium outcomes in the (s k) plan with t=0.3; pA=0.01; pB=0.2; e=2; and w=3 in Eq. 24

The red line in figures 1 and 2 represents the condition in Eq. 19 with strict equality, whereas the blue line represents the condition in Eq. 20. In this case, where firm A has a technology advantage, and its foreign market is relatively large (Region R of diagrams), it will chose GF while firm B will chose M&A. By symmetry, the opposite strategies are chosen in the region P of the diagrams. When w is reduced, these two indifference lines shift upwards and downwards respectively, and when they shift positions, the equilibrium shifts from R=(GF, GF) and P=(M&A, M&A) in Figure 1 and 2 expand, otherwise, T=(GF, M&A) and S=(M&A, GF,) retract. Since the two indifference lines are always parallel (Fig 3), no parameter combination allows both R=(GF, GF) and P=(M&A, M&A) to be equilibrium within the feasible (s,k) space.

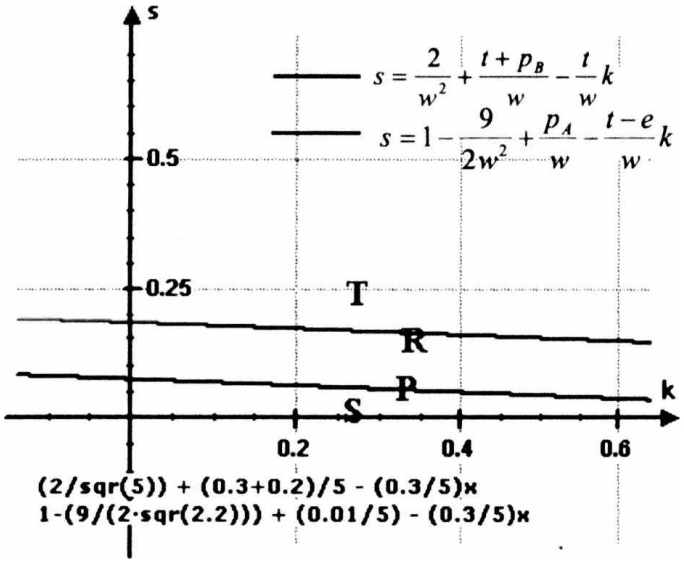

Fig. 3. Equilibrium outcomes in the (s,k) plan with t=0.3; p_A=0.01; p_B=0.2; e=0; and w=5

As to technological asymmetry (captured by the parameter k), the probability that Eq. 17 (Eq. 18) holds and thus that firm A (firm B) establishes a new subsidiary abroad is increasing (decreasing) in k:

$$\frac{\partial LHS(17)}{\partial k} = t\frac{2(w.s-(t(1-k)+p_2))}{4} > 0 \quad (21)$$

$$\frac{\partial LHS(18)}{\partial k} = -t\frac{2(w(1-s)-(t(1-k)+p_2))}{9} < 0 \quad (22)$$

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 enjoy –ceteris paribus- higher variable profits than its competitor. The advantage of the leading firm is greater with the lower the cost of cross border internal technology transfer (the higher t 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 values of the parameters.

5. Conclusion

In the literature of theoretical industrial organization, study of why firms decide to enter a foreign market through GF or M&A is at initial stage. So far, not many studies have succeeded in identifying what kind of firms chooses to make a cross border M&A, and what kind of firms choose instead to be acquired by foreign firms. Our analysis shows that the acquiring firm always gains 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. We show that an acquisition must generate strong synergy effects to be more profitable than a strategy where both firms remain purely national. However, a prisoner's dilemma structure may force both firms to GF, and in that case, an M&A may be more profitable even without synergy effects.

We considered both the gains from implementing a best practiced 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.

In this paper, we applied a simple bargaining model to determine the identity of the acquirer. Our model contains important features that play a pivotal role in deciding the investment choice between conducting an acquisition M&A and establishing a new subsidiary through GF. In our model, we characterized GF choice as cooperation, and M&A choice as defection in the Prisoner's dilemma problem.

In future works, we consider a new strategy in FDI game by spatial prisoner's dilemma, the logical function strategies which take into account two last actions of the opponents instead of one in Tit-for-tat.

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Mô hình hóa đầu tư FDI bằng mô hình Prisoner's Dilemma: Đầu tư từ đầu (Hợp tác) hay Sát nhập (Bất hợp tác)

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Đầu tư trực tiếp nước ngoài FDI là một luồng quỹ hỗn tạp, bao gồm cả mua bán/sát nhập (M&A) hay đầu tư từ đầu (GF). Khi một công ty đắn đo giữa hai lựa chọn trên cũng giống như trong mô hình "sự lưỡng nan của hai người tù" (PD) trong lý thyết trò chơi. Chính vì lẽ đó, chúng tôi đã sử dụng mô hình này để mô hình hóa đầu tư trực tiếp nước ngoài. Các điều kiện khi một công ty lựa chọn đầu tư từ đầu đã được thảo luận bằng cách phân tích các trạng thái cân bằng.

Từ khóa: Đầu tư trực tiếp nước ngoài, mua bán/sát nhập, đầu tư từ đầu, sự lưỡng nan của hai người tù, lý thyết trò chơi.