Exchange Rates and Foreign Direct Investment in Oligopolies

by

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July 2002

Abstract

This paper examines the effects of exchange rates on R&D activities and international strategy choices of the oligopolies. We develop a three-stage game-theoretic model in which two firms located in two different countries (a developing and a developed one) choose the mode of foreign expansion in the first stage. They decide how much to spend on R&D, and how much to sell in domestic and foreign markets, in the second and the third stages, respectively. According to the results appreciation of developing country's currency may change the decision of the developed country firm from export to foreign direct investment.

JEL Classifications : F23, L10, O34

Key Words : Foreign Direct Investment, exchange rates, R&D.

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1. INTRODUCTION

The relationship between exchange rates and foreign direct investment (FDI) always stands as an important question for economists. The issue has been discussed in both theoretical and empirical literature in the area. Baldwin and Krugman (1989), Caves (1989), Froot and Stein (1991), Goldberg and Kolstad (1995) can be mentioned as the studies addressing this issue.

This paper examines the effects of exchange rates on R&D activities and international strategy choices of the oligopolies. Within our knowledge, there is no study in the literature focusing on the interaction among exchange rates, R&D activities and FDI. There exit quite large amount of studies dealing with the issue of R&D strategy choice of the firms especially in oligopolistic environments. D'Aspremont and Jacquemin (1988) is the leading study in that area. Kamien, et al., (1992), and Petit and Tolwinsky (1996), Kultti and Takalo (1998), Salant and Shaffer (1998) can be mentioned as the important studies focusing on the information transfer issues related with the R&D activities of firms. On the other hand, there are studies analyzing the firms' choice between export and FDI (see Motta and Norman (1996) and Sanna-Randaccio (1996)). However, the studies like Horstman and Markusen (1992) and Either and Markusen (1996) investigate the effect of R&D decision on firms' expansion mode choice without endogenizing the R&D decision. A more recent study connecting both issues and considering both R&D decision and the expansion mode decision within the same model is Petit and Randaccio (2000). In their three-stage model, they showed that multinational expansion and R&D expenditures are positively related and the firm that invests more on R&D is the firm with an exporter rival.

We take Petit and Randaccio (2000)'s model as a basis for this study. The main extensions that we introduce are demand and cost asymmetries and the exchange rates in our model. In the three-stage model, firms are located in two different countries. Country 1 is a developing country that has lower demand for the product produced by these firms, less valuable currency unit and a firm with a less advanced technology. Country 2 is a developed country. The firms choose the mode of foreign expansion in the first stage of the game. They decide how much to spend on R&D, and how much to sell in domestic and foreign markets, in the second and the third stages, respectively.

According to the results, despite the asymmetries introduced to the model multinational firms invest more on R&D compared to exporter firms as in Petit and Randaccio (2000). We also showed that when spill over level is low the exporter developing country firm whose rival is a multinational firm invests less on R&D compared to the exporter developing country firm with an exporter rival. On the other hand, the multinational developed country firm whose rival is an exporter invests more on R&D compared to the exporter firm with an exporter rival.

As stated before the main focus of this study is on how the exchange rate movements affect firms' R&D and international expansion choices. We showed that the sensitivity differences of the R&D expenditure levels to exchange rates becomes more pronounced with an increase in transportation cost level for both firms. According to the numerical results when there is an appreciation in the developing country's currency, the exporter developed country firm may change its strategy from export to FDI. This effect is more pronounced with low spillovers. When the developed country firm spends more on R&D, which is less costly with an appreciation of developing country's currency, there will be a substantial increase in its competitive advantage. Therefore, FDI will become a more profitable strategy for the this firm. However, when the spillover is high, due to the free-rider problem, developed country firm will increase R&D expenditure less (it will even decrease R&D expenditure at sufficiently high spillover levels), thus, FDI may not be attractive in this situation.

This paper is organized as follows. Section 2 includes our theoretical model and results. Numerical results related with the effects of exchange rates on expansion mode choice of the firms are presented in Section 3. Concluding remarks are given in Section 4.

2. THE THEORETICAL MODEL

We consider a model with two countries, namely a developing home country and a developed foreign country. There are two firms, Firm x and Firm y located in Country 1 and Country 2, respectively, producing a homogeneous product. Home country's firm possesses relatively inefficient production technologies. Marginal cost of production of firm x and y in home country's currency unit are assumed to be as follows:

$$MC_x(I_x, I_y) = A_x - \theta(I_x + \alpha e I_y), \qquad (1a)$$

$$MC_y(I_x, I_y) = eA_y - \theta(\alpha I_x + eI_y). \qquad (1b)$$

A_x and A_y are the initial marginal cost levels ($eA_y < A_x$) and I_x and I_y represent the R&D expenditure levels of the firms (in each country's own currency unit). e represents the exchange rate[1] and θ is an R&D efficiency parameter that shows the decline in marginal cost level as a result of an increase in R&D expenditure level. Since it is assumed that the rival firms' R&D expenditures are also effective on firm *i*'s marginal cost level, we introduce a spillover parameter $\alpha \in [0,1]$.

The demand function of Country *j* for this product is assumed to be linear;

$$P_j = a_j - b_j(q_{xj} + q_{yj}), \qquad \text{j} = 1,2 \qquad (2)$$

where P_j is the price level in country *j* in its own currency unit q_{xj} and q_{yj} are the outputs sold in country *j* by firm *x* and firm *y*.

Similar to Petit and Randaccio (2000), we assume three different mode of foreign expansion: Producing at home and exporting to the other country (EXP), foreign direct investment which means producing in both countries (FDI) and no expansion which corresponds to the case where each firm sells only in domestic market (NFE). We allow our firms to choose among these strategies, thus, we may face nine different situations. In this section, we will first focus on two symmetric cases where both firms choose EXP or FDI and one asymmetric case where developing country firm exports the other firm becomes a multinational (FDI).

2.1 *Exporting Duopoly*: Both firms choose to export to the other country's market, therefore the profit functions of the firm *x* firm *y* can be respectively written as

$$\pi_x^{EE} = (a_1 - b_1(q_{x1} + q_{y1}))q_{x1} + e(a_2 - b_2(q_{x2} + q_{y2})q_{x2} - (A_x - \theta(I_x + \alpha e I_y))(q_{x1} + \mathrm{q}_{x2})$$
$$- \mathrm{s}_1 q_{x2} - \gamma \frac{I_x^{\,2}}{2} - F_1 - G_1 \qquad (3a)$$

$$\pi_y^{EE} = (a_1 - b_1(q_{x1} + q_{y1}))q_{y1} + e(a_2 - b_2(q_{x2} + q_{y2})q_{y2} - (eA_y - \theta(\alpha I_x + eI_y))(q_{y1} + \mathrm{q}_{y2})$$
$$- \mathrm{e\,s}_2 q_{y1} - e\gamma \frac{I_y^{\,2}}{2} - eF_2 - eG_2 \qquad (3b)$$

Here, $\gamma I^2/2$ represents the cost of R&D investment (see D'Asperomont….). As

[1] Since country *x* is a developing country *e* is assumed to be greater one.

γ increases clearly the cost of R&D will increase. F_j and G_j (j = 1,2) are country specific fixed costs. G_j is considered as the set up cost, however, F_j captures all firm activities such as advertising, management, distribution costs etc. For the rest of the study, it is assumed for simplicity that $b_1 = eb_2$, $s_1 = es_2$, $F_1 = eF_2$, $G_1 < eG_2$ and $a_1 < ea_2$. The equalities mean that the slopes of demand functions, unit transportation costs and firms' activity specific fixed costs are equal in terms of the currency unit of Country 1 in two countries. $G_1 < eG_2$ means that the set up cost is cheaper in the developing country. This assumption based on the observation that the land and the building cost is lower in developing countries. By the assumption $a_1 < ea_2$, we say that the demand for this product in developed country is higher.

Firms in our model play a three-stage game. In the first stage they choose the expansion mode, in the second stage they decide how much to spend on R&D and finally, in the third stage, they determine how much to sell in domestic and foreign markets. Since in this section, we are considering the case where both firms choose to export, we can compute the last stage Cournot equilibrium output levels as follows:

$$\begin{aligned}
q_{x1} &= \frac{a_1 - 2A_x - (\alpha-2)\theta I_x + e(A_y + s_2 + (2\alpha-1)\theta I_y)}{3eb_2}, \\
q_{x2} &= \frac{e(a_2 + A_y + (2\alpha-1)\theta I_y) - (\alpha-2)\theta I_x - 2(es_2 + A_x)}{3eb_2}, \\
q_{y1} &= \frac{a_1 + A_x - 2e(A_y + s_2) + (2\alpha-1)\theta I_x - e(\alpha-2)\theta I_y)}{3eb_2}, \\
q_{y2} &= \frac{e(a_2 - 2A_y - (\alpha-2)\theta I_y) + (2\alpha-1)\theta I_x + es_2 + A_x)}{3eb_2}.
\end{aligned} \tag{4}$$

Substituting above equilibrium output levels into the profit functions given in (3a) and (3b) and maximizing the profit functions with respect to R&D expenditure levels, we obtain the following reaction functions.

$$I_x = \frac{2(2-\alpha)\theta(a_1 - 4A_x + e(a_2 + 2A_y - s_2 + 2(2\alpha-1)\theta I_y))}{9e\gamma b_2 - 4(\alpha-2)^2\theta^2} \tag{5a}$$

$$I_y = \frac{2(2-\alpha)\theta(a_1 + ea_2 + 2A_x - 4A_y + es_2 + 2(2\alpha-1)\theta I_y))}{9e\gamma b_2 - 4e(\alpha-2)^2\theta^2} \tag{5b}$$

Solving these reaction functions simultaneously we get the Nash equilibrium R&D levels as follows;

$$I_x^{EE} = \frac{m6\gamma b_2(eA_y - 2A_x)}{k} - \frac{m((a_1 + e(a_2 - s_2))(2m(1-\alpha)\theta - 3\gamma b_2)}{k} + \frac{m^2 4\theta(A_x - e\alpha A_y))}{k} \quad (6a)$$

$$I_y^{EE} = \frac{me6\gamma b_2(A_x - 2eA_y)}{ek} - \frac{m((a_1 + e(a_2 - s_2))(2m(1-\alpha)\theta - 3e\gamma b_2)}{ek} - \frac{m^2 4\theta(\alpha A_x - eA_x))}{ek} \quad (6b)$$

where $m = 2(2-\alpha)\theta$ and $k = 27e\gamma^2 b_2^{\,2} - 16(\alpha-2)^2(\alpha^2-1)\theta^4 - 12\gamma b_2(4(1+e)(\alpha-2)^2\theta^2$. $k > 0$ due to the stability condition. It must be noted here that the sensitivity analysis of these R&D expenditure level w.r.t. exchange rate is quite inconclusive. In other words, an increase in exchange rate can either increase or decrease the R&D levels, but the conditions for the sign change of the derivatives of I_x and I_y w.r.t. e are quite complicated for a clear analysis. In the proceeding sections, we will at least compare the sensitivity levels with each other under different foreign expansion modes.

2.2 *Multi-National Duopoly*: In this case, both firms choose to invest in the foreign country. Thus, the profit functions of the firms become

$$\pi_x^{FF} = (a_1 - b_1(q_{x1} + q_{y1}))q_{x1} + e(a_2 - b_2(q_{x2} + q_{y2})q_{x2} - (A_x - \theta(I_x + \alpha e I_y))(q_{x1} + q_{x2}) - \gamma\frac{I_x^{\,2}}{2} - F_1 - 2G_1 \quad (7a)$$

$$\pi_y^{FF} = (a_1 - b_1(q_{x1} + q_{y1}))q_{y1} + e(a_2 - b_2(q_{x2} + q_{y2})q_{y2} - (eA_y - \theta(\alpha I_x + eI_y))(q_{y1} + q_{y2}) - e\gamma\frac{I_y^{\,2}}{2} - eF_2 - 2eG_2 \quad (7b)$$

Solving the game backwards as described before, we obtain the Cournot output levels[2]. Substituting these levels into the profit function and maximizing w.r.t. R&D levels we get the following Nash equilibrium R&D levels for firm x and y respectively:

$$I_x^{FF} = I_x^{EE} - \frac{mes_2(2(1-\alpha)m\theta - 3\gamma b_2)}{k} \quad (8a)$$

$$I_y^{FF} = I_y^{EE} - \frac{ms_2(2(1-\alpha)m\theta - 3\gamma e b_2)}{k} \quad (8b)$$

[2] Cournot equilibrium output levels are not given because they are very similar to the output levels for EXP-EXP. The only difference is the transportation cost. $s_2 = 0$ for FDI-FDI.

Proposition 1: Multinational firms always invest more on R&D compared to exporter firms.

Proof: We know that $k>0$, $m=2(2-\alpha)\theta>0$ and $e>1$. From (6a) and (6b) $3\gamma b_2>2(1-\alpha)m\theta$ for $I_x^{EE}>0$ and $I_y^{EE}>0$, therefore, $I_x^{FF}>I_x^{EE}$ and $I_y^{FF}>I_y^{EE}$. □

As it can easily be seen from (8a) and (8b) the differences between R&D levels under these expansion modes increase with transportation cost. It is important to note here that when we introduce demand and cost asymmetries to the model, Petit and Randaccio (2000)'s result, regarding the R&D expenditure levels under different expansion modes, does not change. FDI still motivates R&D.

Now, we will look at how the sensitivities of R&D levels w.r.t. exchange rates change with the mode of expansion. The differences between the derivatives of I_j^{EE} and I_j^{FF} $(for\, j=x,y)$ w.r.t. e can be computed as follows:

$$\frac{\partial I_x^{EE}}{\partial e}-\frac{\partial I_x^{FF}}{\partial e}=\frac{8(\alpha-2)^3\theta^3(-8m(\alpha-1)^2(1+\alpha)\theta^3-9\gamma b_2(4(\alpha-1)\theta^2+\gamma b_2))s_2}{k^2} \quad (9a)$$

$$\frac{\partial I_y^{EE}}{\partial e}-\frac{\partial I_y^{FF}}{\partial e}=\frac{24(\alpha-2)^2(1-2\alpha)\gamma b_2\theta^3(-2m(\alpha-1)\theta-3\gamma b_2)s_2}{k^2} \quad (9b)$$

As it can easily be seen from (9a) and (9b) the differences between R&D investment levels' sensitivities to exchange rates under different expansion modes are directly related to the transportation cost level. The direction of this relationship can be determined by the relative values of efficiency cost parameter of R&D and spillover level.

Proposition 2: The sensitivity differences of the R&D expenditure levels to exchange rate under different expansion modes intensify with the transportation cost level for both firms.

Proof: Proof is obvious.

This result is very intuitive. When both firms are exporting rather than being multinational enterprises, the effect of a change in exchange rate on R&D expenditure level obviously differs through the transportation cost. When transportation cost is zero, there will be no difference between R&D level sensitivities to exchange rate under different expansion mode. Additionally, it is possible to say that the directions of the relationship between these sensitivities depend on R&D cost-efficiency parameters and spillover levels.

2.3 *Mixed Duopoly*: Here, we will look at the situation where only the firm in Country y chooses to be a multinational firm. Then, we will compare the differences between R&D levels and R&D exchange rate sensitivity levels for the case where both firms are exporting.

For this asymmetric situation the profit function is as given in (3a) for firm x and as given in (7b) for firm y. Solving the game as we did before, we obtain the following R&D equilibrium levels.

$$I_x^{EF} = I_x^{EE} + \frac{ems_2(2m\alpha\theta - 3\gamma b_2)}{k} \tag{10a}$$

$$I_y^{EF} = I_y^{EE} - \frac{2ms_2(m\theta - 3e\gamma b_2)}{k} \tag{10b}$$

Proposition 3: For low spillover levels ($\alpha < 1/2$);

i) The exporter developing country firm whose rival is a multinational firm invests less on R&D compared to the exporter developing country firm with an exporter rival.

ii) The multinational developed country firm whose rival is an exporter invests more on R&D compared to the exporter firm with an exporter rival.

Proof: We know from (6a) that $3\gamma b_2 > 2(1-\alpha)m\theta$. From (10a) $I_x^{EF} < I_x^{EE}$ if $3\gamma b_2 > 2m\alpha\theta$. Obviously, if $2(1-\alpha)m\theta > 2m\alpha\theta$, which holds when $\alpha < 1/2$. $3\gamma b_2 > 2m\alpha\theta$ will always hold. It is also known from (6b) that $3\gamma e b_2 > 2(1-\alpha)m\theta$. From (10b) $I_y^{EF} > I_y^{EE}$ if $3\gamma e b_2 > m\theta$. Similarly, if $2(1-\alpha)m\theta > m\theta$, which again holds when $\alpha < 1/2$, . $3\gamma e b_2 > m\theta$ will always hold. Thus, if $\alpha < 1/2$, $I_x^{EF} < I_x^{EE}$ and $I_y^{EF} > I_y^{EE}$.□

As in Petit and Randaccio (2000), if $\alpha \geq 1/2$, then $I_x^{EF} > I_x^{EE}$ and $I_y^{EF} < I_y^{EE}$ if and only if $3\gamma b_2 < 2m\alpha\theta$ and $3\gamma e b_2 < m\theta$, respectively.

When we look at the sensitivity differences of R&D functions w.r.t. exchange rate for the international exporting and mixed duopoly we obtain the following functions;

$$\frac{\partial I_x^{EE}}{\partial e} - \frac{\partial I_x^{EF}}{\partial e} = \frac{8(\alpha-2)^3\theta^3(2m\alpha\theta - 3\gamma b_2)(4(1-\alpha^2)\theta^2 - 3\gamma b_2)s_2}{k^2} \tag{11a}$$

$$\frac{\partial I_y^{EE}}{\partial e} - \frac{\partial I_y^{EF}}{\partial e} = \frac{24(\alpha-2)^2(1-2\alpha)\gamma b_2\theta^3(2m\alpha\theta - 3\gamma b_2)s_2}{k^2} \tag{11b}$$

Similar with our previous finding, the sensitivity differences become more pronounced for higher transportation cost levels.

Proposition 4: : For high spillover levels ($\alpha \geq 1/2$);

i) The exporter developing country firm's (whose rival is a multinational firm) R&D expenditure level increase more (or decreases less) as a result of an increase in exchange rate compared to the exporter developing country firm with an exporter rival, if its R&D investment level is lower than the latter firm ($2m\alpha\theta > 3\gamma b_2$),

ii) The multinational developed country firm's (whose rival is an exporter) R&D expenditure level increase more (or decreases less) as a result of an increase in exchange rate compared to the exporter firm with an exporter rival, if $2m\alpha\theta > 3\gamma b_2$.

Proof: Since $2m\alpha\theta > (4(1-\alpha^2)\theta^2$ for $\alpha \geq 1/2$, $4(1-\alpha^2)\theta^2 - 3\gamma b_2 < 0$ when $2m\alpha\theta - 3\gamma b_2 < 0$, thus, $\frac{\partial I_x^{EE}}{\partial e} - \frac{\partial I_x^{EF}}{\partial e} < 0$. It can easily be seen from (11b) that when $\alpha \geq 1/2$ and $2m\alpha\theta - 3\gamma b_2 > 0$, $\frac{\partial I_y^{EE}}{\partial e} - \frac{\partial I_y^{EF}}{\partial e} < 0$.□

As we see from the above proposition, when the exporter developing country firm with the multinational rival has a lower R&D level (compared to the case where its rival is also exporter) it responds more pronouncedly to a devaluation in its own country's currency. This result can be explained by the relative cost decrease in R&D. When the rival is a multinational firm the competition in the domestic market is more severe, thus domestic firm whose R&D investment level is low start to spend more on R&D due to cost advantage created by the devaluation. On the other hand, the multinational developed country firm with the exporter rival responds more intensively (compared to the case where it is also an exporter) to the devaluation of the other country's currency for not to loose its existing competitive advantage.

3. THE EFFECTS OF EXCHANGE RATES ON FIRMS' STRATEGIES

In this section we will analyze how firms choose their expansion mode and how the R&D activity parameters and exchange rates affect these choices. As we stated before, in our game, each firm has three strategies: exporting, FDI or no foreign expansion. In order compute the Nash equilibrium of this expansion mode game we need to compare the profit levels of each firm under each of these expansion modes. Unfortunately, algebraic comparisons is quite complicated, therefore we are not able to present the analytical solution of this game. However, the numerical results given in the following tables will help us to understand the nature of the equilibrium and the effects of the important parameters on equilibrium. We computed the game matrixes given in Table 1, Table 2 and Table 3 for the values of the parameters: a_1=50, a_2=55, b_2=2, A_x=8, A_y=4, s_2=1.9, γ=1, θ=0.3, G_1=20, G_2=22, F_2=10, α = {0.0, 0.5, 0.9}, *e* = {1.1, 1.5,1.9}. Tables are computed at different values of the exchange rates and spillover parameter because these are the important parameters affecting the equilibrium.

As it is seen from Table 1 when *e* = 1.9, without depending on the value of α, both firms choose to export at the equilibrium. Petit and Randaccio (2000) showed that when there is a reduction in set up cost levels, equilibrium moves from Export-Export to FDI-FDI. Here, we will focus on the effects of exchange rate on the equilibrium.

		Firm y		Firm y		Firm y	
		EXP		**FDI**		**NFE**	
α=0.0							
Firm x	**EXP**	**240.0***	**285.5***	229.7	284.4	338.0	61.6
	FDI	238.0	263.0	227.5	261.8	338.8	51.2

	NFE	14.0	618.9	5.0	618.1	78.4	232.6
α=0.5							
Firm x	**EXP**	**258.1***	**286.8***	248.6	284.7	347.3	66.1
	FDI	256.1	265.2	246.6	263.1	347.5	56.0
	NFE	21.5	618.9	12.2	617.1	84.5	235.8
α=0.9							
Firm x	**EXP**	**265.1***	**286.0***	256.0	283.4	353.8	66.3
	FDI	263.0	264.8	253.9	262.3	353.7	56.2
	NFE	27.0	617.7	17.5	615.3	89.5	238.5

Table 1. The case for e = 1.9 (* represents Nash equilibrium).

We observe from Table 2 that when $e = 1.5$ and low α is low then the equilibrium moves to Export-FDI. The reduction in e corresponds to an appreciation of the developing country's currency. As a result of this appreciation there will be a decrease in transportation cost and a relative increase in the set up cost in developing country. At first, one thinks that the equilibrium should move from FDI-FDI to Export-Export as a result of such appreciation. However, we know that the original equilibrium is Export-Export. We also know from Proposition 3 that when α is low (or α is high and $3\gamma e b_2 < m\theta$) the multinational developed country firm whose rival is an exporter invests more on R&D compared to the exporter firm with an exporter rival. Due to the appreciation, R&D becomes relatively less costly for this firm and therefore, it spends more on R&D. As a result of this, its competitive advantage substantially increases. This effect dominates the other negative effects and therefore, it becomes more profitable for this firm to choose FDI strategy. As a result equilibrium turns out to be Export-FDI. In fact, at our numerical values of the parameters $3\gamma e b_2 < m\theta$ never hold thus, $I_y^{EF} > I_y^{EE}$ is valid for all games. But, we can easily obtain from (10a) and (10b) that the differences between I_y^{EF} and I_y^{EE} decrease as α increases. Therefore, it is possible to say that when exchange rate is not sufficiently low, the advantage of R&D increase is not sufficient to change the equilibrium from Export-Export to Export -FDI at high α levels.

		Firm y		Firm y		Firm y	
		EXP		**FDI**		**NFE**	
α=0.0							
Firm x	**EXP**	189.2	266.8	**179.4***	**267.1***	294.0	94.9
	FDI	186.4	248.4	176.4	248.6	292.6	83.8
	NFE	26.4	523.2	17.6	523.7	114.2	262.6

α=0.5							
Firm x	**EXP**	**205.2***	**270.2***	196.1	269.6	302.1	100.7
	FDI	202.3	252.7	193.2	252.1	300.2	89.9
	NFE	34.0	523.7	25.2	523.3	120.4	266.8
α=0.9							
Firm x	**EXP**	**211.2***	**270.2***	202.4	269.2	306.3	102.8
	FDI	208.2	253.2	199.5	252.2	304.1	92.0
	NFE	39.4	522.6	30.4	521.6	125.5	270.2

Table 2. The case for e = 1.5 (* represents Nash equilibrium).

When exchange rate decreases more, as we observe from Table 3, the equilibrium will always move to Export-FDI even at high α levels. This happens due to the relatively less costly R&D expenditure increase which brings a substantial production cost advantage to the developed country firm.

		Firm y		Firm y		Firm y	
		EXP		**FDI**		**NFE**	
α=0.0							
Firm x	**EXP**	146.8	266.8	**137.5***	**268.5***	282.5	132.9
	FDI	143.3	252.4	133.9	254.0	279.4	120.7
	NFE	45.5	446.4	37.0	448.2	173.6	293.0
α=0.5							
Firm x	**EXP**	160.6	273.6	**151.9***	**274.5***	289.0	140.6
	FDI	157.0	260.2	148.2	261.2	285.6	128.8
	NFE	53.5	448.4	45.0	449.4	180.0	298.8
α=0.9							
Firm x	**EXP**	165.6	275.1	**157.2***	**275.6***	290.9	145.3
	FDI	161.8	262.2	153.4	262.8	287.1	133.6
	NFE	58.9	447.6	50.3	448.2	185.2	303.6

Table 3. The case for e = 1.1 (* represents Nash equilibrium).

4. CONCLUSION

This paper investigated how the exchange rates affect R&D activities and international strategy choices of the firms in oligopolies. In our three-stage game, two firms located in two different countries (a developing and a developed one) choose the mode of foreign expansion in the first stage, how much to spend on R&D in the second stage, and how much to sell in domestic and foreign markets in the third stage. Results showed that appreciation of the developing country's currency could cause the exporter developed country firm to change its strategy to FDI. This effect is stronger when the spillover parameter is low. The reason of this strategy choice is the possibility of spending more on R&D at a less cost (because e is lower) and therefore increasing the competitive advantage. When the spillover is high, due to the free-rider problem, developed country firm will increase R&D expenditure less (it will even decrease R&D expenditure at sufficiently high α levels), thus, FDI may not be attractive in this situation.

Usually, it is believed that developing countries becomes more attractive for FDI as a result of a depreciation of the domestic currency. However, this paper showed us that situation might be reverse when we endogenize R&D. Because, FDI also motivates R&D and the competitive advantage obtained from higher R&D level can make FDI a better choice under appreciation instead of depreciation. It is of course clear that due to the restricting assumptions of our model and complexity of calculations these findings are not very general. But, at least, they show us there are situations that we can observe such results.

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