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A Multinational Corporation Microeconomic Model for Exchange Rate and FDI

UN MODÈLE MICROÉCONOMIQUE D'UNE SOCIÉTÉ MULTINATIONALE POUR LE TAUX DE CHANGE ET L'IDE

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Abstract: This paper analyzes how exchange rate affects the direct investment by a multinational corporation model in which two factories of the identical corporation located in two different countries in the pursuit of the maximal profits. we set up hypotheses and give the derivation of the model through which we draw a conclusion: the real exchange rate has a negative influence on FDI by the wealth and cost effects. And we also find the experiment test is in support of the conclusion firmly.
Key words: Exchange Rate; FDI

Résumé: Cet article analyse comment le taux de change affecte les investissements directs en utilisant un modèle d'une société multinationale dont deux de ses usines se situent dans deux pays différents dans le but de maximiser les profits. Nous établissons des hypothèses et donnons la dérivation de ce modèle à travers lequel nous tirons une conclusion: le taux de change réel a une influence négative sur l'IDE par les effets de richesse et de coût. Et nous trouvons également que notre essai approuve fermement la conclusion.
Mots-Clés: taux de change; IDE

1. LITERATURE REVIEW

Form the existed references, Aliber, an American economist, is the first person who make a research on the influence form exchange rate to FDI. In the early of 1970, he anticipated the floating exchange rate would have an influence on FDI, since then, he put forward a capitalization theory. Interestingly, it is Kohlhagen who firstly erected an economics model about the above issue. In 1977, he doubted "the same

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price principle" and fingered out the influence between the exchange rate and FDI. From 1977 to 1988, Japanese Yen appreciated with respect of Dollar drastically and at the same period the American assets were purchased by Japanese individuals in enormous quantity so hundreds of thousands Yen flowed into America. The fire sales phenomena appeal people's interest in the influence of the exchange rate to FDI. In 1985, Cushman discussed the issues in an innovational paper: Real Exchange Rate Risk, Expectation and the Level of FDI. Since then, a large number of references in the argument on this issue emerged from different respects or using different models and methods, in which there are some valuable viewpoints such as the relative cost theory, the wealth effects theory, the risk aversion theory, the merging special assets theory, the exchange rate regime theory, and so on. My paper also discusses the ER-FDI issue but when I argue my opinion, I bring forward a theoretical model that can discuss three effects simultaneously and can be supported by experimental data successfully. This paper starts from the classical factory model adopting the maximal profit principle to set up the theoretical model under a set of assumptions. Subsequently, we arrive at a conclusion: the real exchange rate affects FDI negatively by means of the wealth effect , cost effect and real exchange rate effect. In the end, we prove the experiment data is consistent with the conclusion.

2. THEORETICAL MODEL

2.1 Hypotheses

1st. There are three countries in the world including a mother country which casts FDI to colonial countries notated by M and the two countries which receives FDI notated by A and B.

2nd. The multinational corporation in M invests directly to the two factories in A and B respectively, whose products are sold to M.

3rd. The two factories in A and B produce the identical products of which the prices are decided by the multinational corporation in M.

4th. The technology transferred from M to A and B is the diminishing returns to scale and the mature one as well.

5th. The productive resources can flow between countries freely.

6th. To omit the trading costs such as the transportation, customs and so on.

7th. Floating exchange rate.

8th. To accept the maximal profit principle.

2.2 Derive the ER-FDI Model

In the light of making an analysis conveniently, we employ the Cobb-Douglas product function which represents the multinational corporation's behavior. Accordingly, the output of the factory in A is $Y_A = \gamma K_A^{\alpha} L_A^{\beta}$ in which the right corner notation A represents the variable with the regard to the factory in A. Then the multinational corporation's profit that happens in A is:

$$\pi_A = P\gamma K_A^{\alpha} L_A^{\beta} - e_A(r_A K_A + w_A L_A) \tag{1}$$

where P is the product's price marked by country M's currency,

γ is a parameter.

K_A is the FDI from M to A quoted by country A's currency,

L_A is the labor quantity in the factory of A,

e_A is the nominal exchange rate that uses country M's currency quoting A's.

r_A is the capital's rent quoted by country A's currency, and

w_A is the labor's price quoted by country A's currency.

Similarly, we use the equation to describe the multinational corporation's profit that happens in B:

$$\pi_B = P\gamma K_B^{\alpha} L_B^{\beta} - e_B(r_B K_B + w_B L_B) . \quad (2)$$

Thereafter, the total profit from the factories of A and B is:

$$\pi = P(\gamma K_A^{\alpha} L_A^{\beta} + \gamma K_B^{\alpha} L_B^{\beta}) - e_A(r_A K_A + w_A L_A) - e_B(r_B K_B + w_B L_B) . \quad (3)$$

According to the maximal profit principal, the FOC is:

$$\frac{\partial \pi}{\partial K_A} = P\gamma\alpha K_A^{\alpha-1} L_A^{\beta} - e_A r_A = 0 \quad (4)$$

$$\frac{\partial \pi}{\partial K_B} = P\gamma\alpha K_B^{\alpha-1} L_B^{\beta} - e_B r_B = 0 \quad (5)$$

$$\frac{\partial \pi}{\partial L_A} = P\gamma\beta K_A^{\alpha} L_A^{\beta-1} - e_A w_A = 0 \quad (6)$$

$$\frac{\partial \pi}{\partial L_B} = P\gamma\beta K_B^{\alpha} L_B^{\beta-1} - e_B w_B = 0 \quad (7)$$

and then rewrite the equation（4）, taking logarithm, we have:

$$Log(P\gamma\alpha) + (\alpha-1)Log(K_A) + \beta Log(L_A) = Log(e_A r_A) . \quad (8)$$

Analogously, the same thing happens to the equation（6）:

$$Log(P\gamma\beta) + \alpha Log(K_A) + (\beta-1)Log(L_A) = Log(e_A w_A) . \quad (9)$$

The equation system consisted of (8) and (9) will be solved out after cancelling $Log(L_A)$, therefore, we get the following formula (10):

$$(1-\alpha-\beta)Log(K_A) = -\left[(1-\beta)Log(e_A r_A) + \beta Log(e_A w_A) + M\right] \quad (10)$$

where $M = Log(P\gamma) + (1-\beta)Log(\alpha) + \beta Log(\beta)$.

By similar method, we also can get the equation (11) from（5）and（7）:

$$(1-\alpha-\beta)Log(K_B) = -\left[(1-\beta)Log(e_B r_B) + \beta Log(e_B w_B) + M\right] \quad (11)$$

so when we subtract（11）from（10）, the equation (12) comes out:

$$(1-\alpha-\beta)Log\left(\frac{K_A}{K_B}\right) = -\left[(1-\beta)Log\left(\frac{e_A r_A}{e_B r_B}\right) + \beta Log\left(\frac{e_A w_A}{e_B w_B}\right)\right] . \quad (12)$$

Finally, rewriting the formula（12）, we get the ultimate result:

$$Log(\frac{K_A}{K_B}) = -(1-\alpha-\beta)^{-1}\left[(1-\beta)Log\left(\frac{e_A r_A}{e_B r_B}\right)+\beta Log\left(\frac{e_A w_A}{e_B w_B}\right)\right]. \quad (13)$$

The above formula, we call it ER-FDI model, makes sense, by which we can analyze how exchange rate affects the foreign direct investment from the multinational corporation to the factories of country A and B, and the influence channel including the relative cost effect, the relative wealth effect and the real exchange rate effect.

3. MODEL ANALYSIS

3.1 Relative Cost Effect

Thanks to the assumption 1.4, the inequation $(1-\alpha-\beta)>0$ holds. we take derivative to the equation (13):

$$\frac{\partial Log(\frac{K_A}{K_B})}{\partial Log(\frac{e_A w_A}{e_B w_B})} = -(1-\alpha-\beta)^{-1}\beta < 0 \quad (14)$$

We can employ the expression $Log(\frac{K_A}{K_B})$ to represent the ratio of FDI between country A and B, and $Log(\frac{e_A w_A}{e_B w_B})$ to represent the relative cost. When the quantity of the latter rises, the level of relative cost increase accordingly. Since the wage cost is the important ingredient in the total expense and the vital factor to attract foreign investment, we employ the relative wage to represent the relative cost.

Meanwhile $Log(\frac{e_A w_A}{e_B w_B})$ can fluctuate as a result of the change of the nominal exchange rate $\frac{e_A}{e_B}$ .If $\frac{w_A}{w_B}$ we fix the value of and if the nominal exchange rate $\frac{e_A}{e_B}$ appreciates，the value of $Log(\frac{e_A w_A}{e_B w_B})$ will increase.

So according to (14), we can draw a conclusion that when the nominal exchange rate of country A appreciates, the relative wage cost of A increases too and subsequently, the FDI received by country A decreases. This is what we call relative cost effect channel in ER-FDI model. The details of the channel are illustrated as following.

Appreciation ⟶ Relative cost increase ⟶ FDI decrease

Depreciation ⟶ Relative cost decrease ⟶ FDI increase

3.2 Relative Wealth Effect

If the deposit of capital held by people could be looked as wealth, such wealth should be accounted by some one country's currency. Now we use the cash balance equation $M = kPY$ in which M is the stock of money, K is the ratio parameter of the stock money and the total wealth, P represents the level

of price, and Y is the wealth variable. Therefore, $M_A = k_A P_A Y_A$ (15)

$$M_B = k_B P_B Y_B, \quad (16)$$

and according to the purchase parity, we have

$$\frac{e_A}{e_B} = \frac{\frac{P_M}{P_A}}{\frac{P_M}{P_B}} = \frac{P_B}{P_A} \quad . \quad (17)$$

Afterwards, bringing（15）and（16）into (17),we have

$$\frac{e_A}{e_B} = \frac{M_B k_A}{M_A k_B}(\frac{Y_A}{Y_B})^{-1} \quad . \quad (18)$$

Then taking (18) into the equation (13) and rewriting, we get

$$Log(\frac{K_A}{K_B}) = -(1-\alpha-\beta)^{-1}\left[Log\left(\frac{M_B k_A}{M_A k_B}(\frac{Y_A}{Y_B})^{-1}\right) + (1-\beta)Log\left(\frac{r_A}{r_B}\right) + \beta Log\left(\frac{w_A}{w_B}\right)\right] \quad .(19)$$

To take the derivative for (18),

$$\frac{\partial(\frac{e_A}{e_B})}{\partial(\frac{Y_A}{Y_B})} = -\frac{M_B k_A}{M_A k_B}(\frac{Y_A}{Y_B})^{-2} < 0 \quad . \quad (20)$$

To take the derivative for (19),

$$\frac{\partial Log(\frac{K_A}{K_B})}{\partial Log(\frac{Y_A}{Y_B})} = (1-\alpha-\beta)^{-1} > 0 \quad (21)$$

The expression (20) tells us that when the currency of country A appreciates with respect to the currency of country B, the wealth of country A will decrease relative to country B. The expression (21) draws a conclusion that when the country A's wealth decreases referent to country B, the decreasing of FDI in country A will happen. Simply speaking, as two countries expect to introduce the FDI from the same developed country, the exchange rate plays an important role in the game. The relative wealth effect can be demonstrated as following.

Appreciation ⟶ Relative wealth decrease ⟶ FDI decrease

Depreciation ⟶ Relative wealth increase ⟶ FDI increase

3.3 The Comprehensive Effect—The Real Exchange Rate Effect

The real exchange rate is the relative commodity price of two countries adjusted by the nominal exchange rate of the two countries. The real exchange rate also can be written by the following

mathematic expression: $e = E\frac{P_f}{P_d}$ where E is the nominal exchange rate, P_d is the domestic price level, and P_f is the foreign price level.

We rewrite the equation (13) as

$$Log(\frac{K_A}{K_B}) = -(1-\alpha-\beta)^{-1}\left[(1-\beta)Log\left(\frac{\frac{e_A r_A}{r_M}}{\frac{e_B r_B}{r_M}}\right) + \beta Log\left(\frac{\frac{e_A w_A}{w_M}}{\frac{e_B w_B}{w_M}}\right)\right] \tag{22}$$

where r_M and w_M are the capital rent and wage in mother country respectively.

In the equation (22), $\frac{e_A r_A}{r_M}$ is one kind of real exchange rate denoted by capital's price, and similarly $\frac{e_A w_A}{w_M}$ is another kind of real exchange rate represented by the labor's price. Hence, we can say that $\frac{\frac{e_A r_A}{r_M}}{\frac{e_B r_B}{r_M}}$ is a relative real exchange rate between country A and B according to the capital's price and $\frac{\frac{e_A w_A}{w_M}}{\frac{e_B w_B}{w_M}}$ also is a relative real exchange rate of A and B according to the labor's price. So the expression in the big bracket of the equation (22) is the weighted average of the relative real exchange rate defined by capital price and labor price in which the β and$(1-\beta)$ are two individual weights. Generally speaking, the real exchange rate modified by CPI but as far as the multinational corporation concerned, the capital and labor are the very factors which are so important, and therefore we use the weighted average of capital and labor price to describe the real exchange rate. Now we take R to represent the relative real exchange rate from country A to B:

$$R = \left[(1-\beta)Log\left(\frac{\frac{e_A r_A}{r_M}}{\frac{e_B r_B}{r_M}}\right) + \beta Log\left(\frac{\frac{e_A w_A}{w_M}}{\frac{e_B w_B}{w_M}}\right)\right] \tag{23}$$

To bring the equation (23) into (22) and take derivative, we get:

$$\frac{\partial Log(\frac{K_A}{K_B})}{\partial R} = -(1-\alpha-\beta)^{-1} < 0 \tag{24}$$

The above expression tells us that the real exchange rate can also influence FDI and the FDI flowing into country A will decrease as long as the real exchange rate of A appreciates with reference to country B, and vice versa. This is called the real exchange rate effect.

4. CONCLUSIONS

The real exchange rate effect takes simultaneously all the contents into consideration in the right hand of the equation (13) including the relative wealth effect and the relative cost effect, therefore, it is the integrated effect which reflects the influence from exchange rate to FDI ultimately. This is the reason why we call it integrated effect. For an open economy, its real exchange rate represents the changes of the fundamental economic factors and the real exchange rate also is the basic price variable adjusted the external and internal economic relationship. The more dependent on the external environment the economy is the more important role the real exchange rate plays.

5. EMPIRICAL ANALYSIS

5.1 The Experiment Model Designing

The conclusion verified by the experiment test is that the real exchange rate can also influence FDI and the FDI flowing into country A will reduce as long as the real exchange rate of country A appreciates comparing with country B, vice versa. According to this conclusion, we design the following experiment model:

$$Log(\frac{FDI^A}{FDI^B}) = C_1 + C_2 Log(\frac{RER^A}{RER^B}) + C_3 Log\left[\frac{GDP^A(-1)}{GDP^B(-1)}\right] + C_4(G^A - G^B) + C_5 Log(\frac{OPEN^A}{OPEN^B}) \quad (25)$$

where FDI^A and FDI^B represent respectively the foreign direct investment from the mother country M to the colonial countries A and B; C_1 is the intercept of the regressive equation; RER^A and RER^B are the real exchange rates of country A and B; $GDP^A(-1)$ and $GDP^B(-1)$ are the one term lag GDP of country A and B; $OPEN^A$ and $OPEN^B$ are the opening degree indexes calculated by the sum of import and export divided by GDP.

According to the result of our theoretical model, the sign of the parameter C_2 should be positive.

5.2 Data Collection

The real exchange rate is the ratio of the price level between two countries adjusted by nominal exchange rate and it can be expressed by a formula: $RER = E\frac{P_f}{P_d}$,where E is nominal exchange rate notated by a direct quotation; P_d is a domestic price level; P_f is a foreign price level. In econometric practice, the price level can be accounted by CPI to form the real exchange rate based on payout approach or by GDP deflator to form the real exchange rate based on cost approach. Our ER-FDI model uses the weighted average of capital and labor price to represent the real exchange rate, as a result, our experiment model

adopts GDP deflator to describe the price level.

Meanwhile, the theoretical model is in need of the FDI with export orientation so that it goes along with the assumption that the price of product can't be affected by exchange rate. Under this situation, we consider the FDI data from USA to Thailand, Indonesia, India, Korea, Japan and China during 1985-2007 as our sample. All the above six countries are regarded as the export oriented countries. Afterwards, when we look the other five countries as the referent countries we can compare the data of China to theirs. Consequently, there are five group data we can get. The reasons why we exert the above procedures is on one hand the level of exchange rate will fluctuate comparing with other five countries since the nominal exchange rate between USA and China is considerable stable and on the other hand when we make such comparison we can observe how the real exchange rate affect the FDI as the mother country casts FDI to China and the five other countries.

The USA FDI data is collected from the NBER web site and we get the USA FDI data to different countries from 1985 to 2007. The GDP and economic growth data of Thailand, Indonesia, India, Korea, Japan and China are collected from the WEO database of IMF. The export and import, nominal exchange rate and GDP deflator come from IFS database of IMF. When we calculate the real exchange rate, the GDP deflator of USA and the other six countries in 2000 is 100 so we needn't adjust the base.

5.3 Econometric Analysis

Bringing data to the experiment model, we have the following results:

China	C_1	$LOG(RER^A/RER^B)$	$LOG(GDP^A(-1)/GDP^B(-1))$	(G^A-G^B)	$LOG(OPEN^A/OPEN^B)$	of obs.	Adj.R^2	F-value
India	6.15	0.34	2.21**	0.02	-2.22**	23	0.78	16.16
	(4.28)	(0.79)	(4.07)	(0.97)	(-2.98)			
Indonesia	38.60	0.68***	6.04***	0.04**	-0.90***	23	0.97	198.71
	(13.83)	(6.55)	(15.98)	(3.39)	(-4.64)			
Japan	8.89	0.76***	1.58***	0.04	-2.11***	23	0.96	124.15
	(11.24)	(4.41)	(7.04)	(2.53)	(-5.17)			
Korea	20.51	1.04**	3.44***	0.04	-1.48	23	0.85	25.10
	(7.25)	(0.63)	(7.81)	(2.49)	(-2.94)			
Thailand	-0.59	0.75***	2.71***	0.03*	-0.87	23	0.95	100.92
	(-1.93)	(6.23)	(14.22)	(3.31)	(-2.76)			

（Note：***，**and*represent the significant level at 1%，5%and10% individually）

The above results are calculated by Eviews 5.0 software. In view of the regressive result, we find out that the FDI ratio of China to other five countries are affected by real exchange rate significantly, so the sign of C_2 are positive in accordance with assumption. Take the Thailand data as an example, which indicates if the Chinese Yuan depreciated referent to Thailand currency, the China FDI from USA would increase with respect of Thailand FDI, and vice versa. Similarly, the other group data can be explained like this way. At the controlling variables side, the parameters of the ratio of one term lag GDP and the difference of economic growth are significant for it proves that the GDP and economic growth really influence FDI inflow. However, the parameters of opening degree are insignificant and the possible reasens are the lag effect of opening degree or the similar open degree of the six countries. In sum, our experiment test firmly supports the conclusion that the real exchange rate affects the FDI as shown in the mathematical model.

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