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A Game Theory View of China and USA FDI Outflows: Static Cournot Model of Complete Information

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Abstract

This study seeks to examine a game theory view of China and USA FDI outflows using the Static Cournot Model of Complete Information to show how the two countries can come into equilibrium. It is specifically aimed at establish, examining and analyzing the best and fair equilibrium on FDI outflows between the two countries. The study uses annual time series data for a range of 1982 to 2016 on both FDI outflows in China and USA. The study finds Game theory to be the efficient framework on finding the equilibrium of the conflict through Cournot Duopoly Model. The study employed cointegration analysis and OLS method to achieve the objective. The results showed that when game theory is applied in a static situation with complete information, Nash equilibrium is established both when the countries decide to cooperate or not to cooperate. But the gains are much higher when the countries decide to cooperate. The main conclusion is that, there is a conflict solving solution to the battle on FDI outflows between these countries if they decide not to cooperate. However, if both countries decide to cooperate then they will monopolize the FDI outflows market by higher levels and maximize the total gains.

Key words

Game Theory, FDI outflows, Nash equilibrium, Cournot model

JEL Codes: B27, C70, C72, C73

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1. Introduction

1.1. An overview of the US and China's International investment

China's International trade is closely attached to FDI, as about 46% of the Nation's Imports and Exports are conducted by foreign Invested Enterprises (FIE's). China's foreign trade has expanded rapidly and this makes it to become the largest merchandise exporting country, followed by the United States, Germany and Japan. Aiming at expanding its economy and trade, China revisited its International Investment policies. In 2000, China adopted a "Going Global Strategy" and hence encouraged competent enterprises to invest overseas. Being the leading economies in the world, China and the United States have been both, the two principal receivers of FDI in recent decades and also the key benefactors of direct investment to the rest of the world. This is mainly factual for the United States, the most advanced economy in terms of technology worldwide.

The outward direct investment stock for the United States was $4.5 trillion, as of the end of 2012, which is about a quarter of the entire world FDI. Apart from being a relative new-comer to outward investment, China's stock of outward direct investment has been increasing promptly. The Ministry of Commerce in China stated $ 532 billion as an outward stock for the year ended 2012. This sum had fully-fledged to $660 billion by the end of the year 2013. United States and China are competing to fulfill all their driving factors for foreign direct Investment worldwide. These factors include, making money, advancing their technologies, Diversifying Investments, building brands and many others.

1.2. Statement of the problem

After its opening up to foreign trade and Investment, China has been among the World's fastest growing economies, which made it to emerge as a major global economic power. The economic growth of China has considerable implications for the United States, hence raised concern among many United State policy makers. This economic rise has raised concerns as to how China's growth will affect United State economic interests and influence global economic policies. Many trade disputes between the United States and China have overshadowed the benefits derived from the trades alone. This is the reason that Price and Smart (2013) called the economic relationship between the two countries "… partially developed, insufficiently balanced, and politically fragile". As a result, tensions have gradually become the roadblock for investment growth when they are not resolved fairly.

Due to the common battle/conflict between the two countries economy-wise, this study find Game theory to be the efficient framework on finding the equilibrium of the conflict. The objective of this study is to establish, examine and analyze best and fair equilibrium on FDI outflows for both player countries. This study uses Static Cournot model with complete information to show how the two countries can come into equilibrium. This will also show how game theory is applied in economics. An important question to research on is how the Outward Foreign direct investment could be optimal for the two countries.

2. Literature review

2.1. Game Theory and Cournot Model

This is an instrument that analyzes strategic conduct by considering in what manner participants anticipate others to act. Game theory is used in finding out the best outcome from a number of choices by analyzing the strategies (costs and benefits) to each independent player as they contest with each other. The game theory explores the likely results of a state where by two or more rival parties look for the course of action that best benefits. Since each possible outcome is resulting from the combinations of instantaneous actions by each party there is no variables are left to chance. As one of the benchmarks of game theory, Cournot (1983) anticipated Nash's definition of equilibrium in the framework of a certain duopoly model.

2.2. Some Literatures on US-China International Investments

The 2007 United Nations report, for example, points out that China is a major capital provider for developing countries in Africa (UNCTAD, 2007), followed by the United States. China's outward investment, therefore, has substantial implications for the economic development of the world economy in general and for developing countries in particular. The interaction of competitors becomes more important as the number of competitors is limited to two. Before making price and quantities decisions, every producer has to take into account on both the current strategy of the competitor and his forthcoming responsive actions, to minimize the chances for non-competitive agreements as it might become easier for two producers to coordinate their actions and monitor the implementation of the agreement which will result into monopolistic pricing hence create unfavorable condition for consumers, (Romualdas and Algirdas, 2008). When discussing on the importance of FDI Outflows, four main reasons have been identified as motives for Multinational Corporations (MNCs) to undertake international production activities - resource seeking, efficiency seeking, market seeking and strategic asset seeking (Dunning, 2000; Mallampally and Sauvant, 1999; UNCTAD, 1998). The market seeking MNCs stresses on the buying power of the local market, the size of the market, together with the growth potential of the market (Scaperlanda and Balough, 1983; Lucas, 1993; Love and Lage-Hidalgo, 2000; Yang *et al.,* 2000). Chakrabarti (2001) states that market factors is the single most widely used determinant of manufacturing FDI flows.

2.3. Application of Game theory in solving Conflicts/for equilibrium

In our every-day lives, we experience many conflicts sometimes without realizing them. It can be very common incidents like shopping in local groceries or any other special events like trading on stock markets. All these conflicts are corrected by Game theory. In showing the importance of resolving conflicts, (Azin *et al*,. 2012) suggested that, conflicts like sharing of expenses or profits between main contractors which might be driven from issues such as project delays or suspensions, differing site conditions, contract changes etc. can lead to non-compensable consequences that can cause considerable loss for both parties involved in the project if they are not peacefully resolved. Adjusted Winner (AW) mechanism, (Masoud, 2000) and Alternative Dispute Resolution (ADR) (Wolf, 2000, Wolf, 2002) used descriptive methods to present case studies on the prevention and resolution of conflicts over water resources. However, (Romualadas and Algirdas, 2008) recommended the application of theoretical models to be reasonable, coherent and careful, combined with strategic management, industrial organization and other sciences, as well as with economic logic for one to get more accurate results as the application of game theory is limited.

3. Methodology of research

3.1. Model Specification (The Cournot Model of Duopoly)

Cournot (1838) anticipated the existence of Nash equilibrium in particular models of duopoly. The Cournot's work is one of the classics of game theory application in economics. This study therefore considers a very simple version of the Cournot model in analyzing equilibrium in the outflow of FDI in China and USA. The model is used to translate an informal statement of the problem into a normal-form representation of the game, and solving for the Nash equilibrium between China and USA as far as FDI outflow is concerned.

To begin, let us consider q_c and q_u be the homogenous quantities of FDI outflow produced by China and USA respectively and that these quantities are continuously divisible. If we consider the rest of the world to be the market for these FDIs, then, P(Q) = a - Q will be the market-clearing price when the aggregate quantity of FDI is $Q = q_c + q_u$ (Gibbons, 1992). In this case, for simplicity we assume that, there are no fixed costs and the marginal cost is constant at *c*. Therefore, the total cost to country *i* of producing quantity q_i of FDI is $C_i(q_i) = cq_i$. We also assume that both countries choose their quantities of FDI simultaneously[1].

After having posed the assumptions of the model, we now translate the problem into a normal-form game of the game theory. Any duopoly game consists of two players, and in our case the players are the countries of China and USA. The strategies available to these countries are the different quantities of FDI outflow each country might produce. Since negative quantities of FDI outflow are not feasible, then each country's strategy space can be represented as $S_i = [0,\infty)$, in which a particular strategy s_i is a quantity of FDI chosen, $q_i \geq 0$.

The payoff to country i as a function of the strategies chosen by it (s_i) and by the other country s_j can be specified as follows. Consider the country's payoff $[u_i(s_i, s_j)]$ to be the profit (π) it gains from the quantities of FDI outflow. According to Gibbons (1992), a general two-player game payoff function in normal form is written as;

$$\pi_i(q_i, q_j) = q_i[P(Q) - c] = q_i[a - (q_i + q_j) - c] \quad (1)$$

To solve for equilibrium, Gibbons (1992, 8) defines the Nash equilibrium as the optimal strategy pair (s_c^*, s_u^*) if and only if for each country i, $u_i(s_i^*, s_j^*) \geq u_i(s_i, s_j^*)$ for every feasible strategy s_i in S_i space. Therefore, for each country i, s_i^* must solve the following optimization problem

$$\max_{s_i \in S_i} u_i(s_i, s_j^*).$$

In the Cournot duopoly model in which our case of China and USA is based, the analogous statement is that the quantity pair of FDI (q_c^*, q_u^*) is Nash equilibrium if for each country i, q_i^* solves the following profit maximization problem

$$\max_{0 \leq q_i < \infty} \pi_i(q_i, q_j^*) = \max_{0 \leq q_i < \infty} q_i[a - (q_i + q_j^*) - c], \ q_j^* < a - c \quad (2)$$

The first-order condition for country $i's$ optimization problem which is both necessary and sufficient is therefore given by

$$q_i = \frac{1}{2}(a - q_j^* - c)$$

According to Gibbons (1992), the equilibrium quantity pair of FDI (q_c^*, q_u^*) is Nash equilibrium if the country's quantity choice of FDI satisfies the following equation;

$$q_1^* = \frac{1}{2}(a - q_2^* - c) \quad (3)$$

$$q_2^* = \frac{1}{2}(a - q_1^* - c) \quad (4)$$

Solving this pair of simultaneous equations by substitution yields;

$$q_1^* = q_2^* = \frac{a-c}{3} \quad (5)$$

Equations *3*, *4* and *5* above fills the theoretical gap of the Cournot model in the construction of the Nash Equilibrium using Game theory. Notice that in this case (Nash equilibrium) no country has incentive to deviate from equilibrium[2]. Equation *5* on the other hand it shows the equilibrium quantity of the product.

[1]This is the key assumption with Cournot (1838) model in which firms choose their quantities simultaneously, as opposed to Stackelberg's (1934) model in which firms choose quantities but one firm chooses before the other.

[2]Here the aggregate quantity is higher, so the associated price is lower and the temptation to increase output is reduced since any attempt to increase output will cause the market-clearing price to fall.

3.1. Econometric Methodology and Estimation Techniques

Before doing empirical estimation of the Cournot model (equation *3* and *4*), it was necessary to identify and understand the premise on which the estimation is based. It is also important to identify other factors that make the estimation possible (Malva, 2014). The key assumption is that both countries choose their quantities of FDI outflow simultaneously. To make the econometric model valid for estimation, other factors are suggested including exchange rate US versus China (*excu*), *GDPu*, and the error term (e) to capture measurement and specification errors (Ahmad, Yasmeen and Ahmad, 2013; Hsing, 1989). With this regard, we modified equation 1 and *2* above into a single equation for simplicity as follows;

$$fdiu_t = \propto_0 + \propto_1 fdic_t + \propto_2 excu_t + \propto_3 gdpu_t + e_t \quad (6)$$

The above equation (equation *6*) makes the econometric model that was analyzed to achieve the objectives of this paper. This model was estimated using a standard way of ordinary least squares method (0LS). Eviews 9 statistical software was used for data analysis.

3.2. Data Type, Description and Sources

This paper used annual time series data for the range of 1982–2016. The variables involved include Foreign Direct Investment outflow of US (*FDIu*), Foreign Direct Investment outflow of China (*FDIc*), Gross Domestic Product of the US (*GDPu*), and exchange rate between China and US (*EXcu*). Foreign Direct Investment outflow of US (*FDIu*) is measured as the percentage of GDP (% of GDP) of the net outflows of the foreign direct investment in the US. Source: Word Bank.

Foreign Direct Investment outflow of China (*FDIc*) refers to the percentage of GDP (% of GDP) of the net outflows of the foreign direct investment in China. Source: Word Bank. Real Gross Domestic Product of the US (*GDPu*) is an inflationary adjusted measure that reflects the value of all goods and services produced in a given year in the US. It is expressed in annual percentages (annual %). Source: World Bank National Accounts Data. Exchange rate between China and US (*EXcu*) is the China's official exchange rate against USD (RMB/USD). It is the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages. Source: Board of Governors of the Federal Reserve System (US)

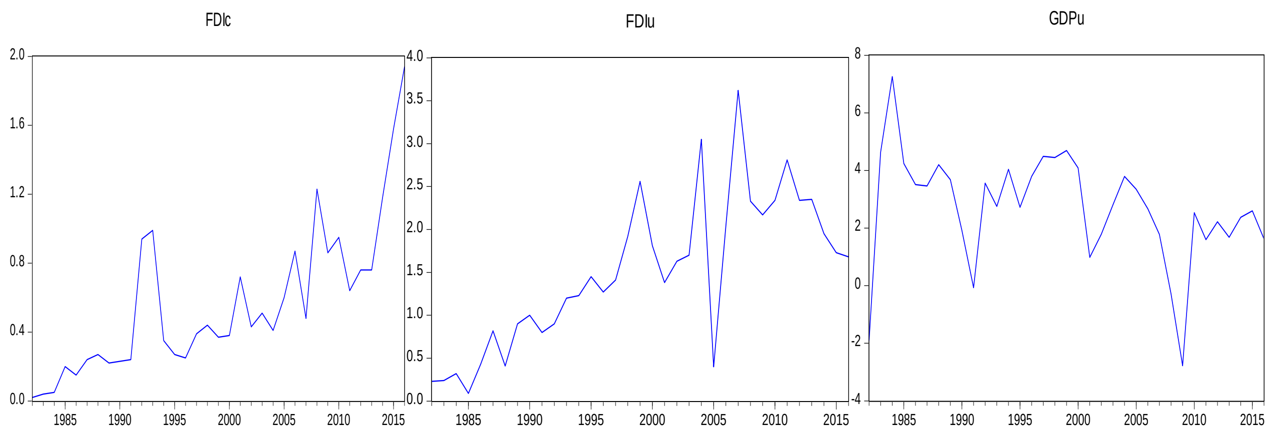
4. Results and discussions

This section presents the results and discussion. It starts with data description (both statistical and time series properties), estimated model and finally diagnostic test.

4.1. Data Description and Statistical Analysis

4.1.1. Graphical Analysis

This was carried out to give a general and quick picture of the variables before estimation.



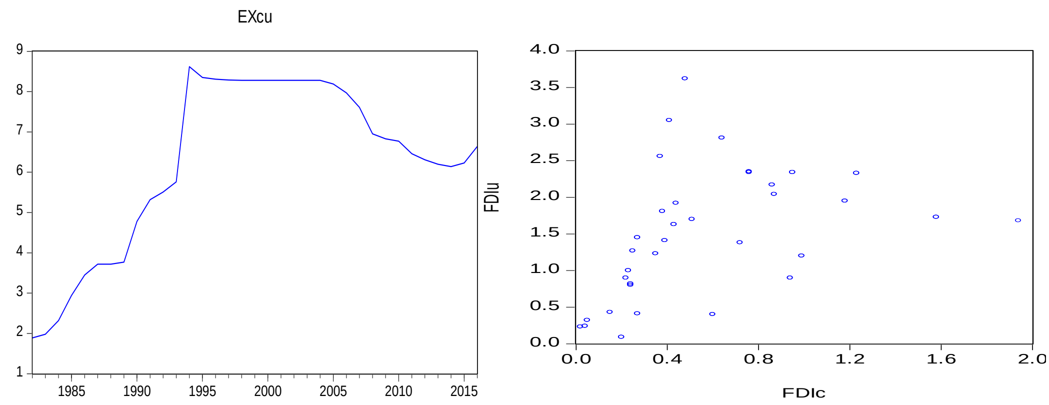


Figure 1. Graphs of the Variables

Generally, the graphs show that there are no clear trends to the variables suggesting that that the variables have no serious trend effects. On the other hand, the scatter diagram suggests that at lower levels (quantities) FDI outflows tend to be concentrated. However, at higher levels (many FID outflows) they tend to be more scattered. This scatterness revels the source of competition between US and China. The competition (riverlness) is due to the fact that the market for FDI is widening and many FIDs are being produced worldwide.

4.1.2. Descriptive Data Analysis and Statistical Test

Table 1. Descriptive Statistics

	FDIU	FDIC	EXCU	GDPU
Mean	1.500286	0.570286	6.256857	2.692286
Median	1.450000	0.430000	6.640000	2.750000
Maximum	3.620000	1.940000	8.620000	7.260000
Minimum	0.090000	0.020000	1.890000	-2.780000
Std. Dev.	0.877900	0.439689	2.110263	1.923496
Skewness	0.269011	1.227376	-0.701450	-0.754602
Kurtosis	2.473655	4.339148	2.255597	4.436164
Jarque-Bera	0.826156	11.40289	3.678304	6.329554
Probability	0.661611	0.003341	0.158952	0.042224
Sum	52.51000	19.96000	218.9900	94.23000
Sum Sq. Dev	26.20410	6.573097	151.4092	125.7944
Observations	35	35	35	35

The mean, maximum and minimum values, standard deviations and the number of observations involved are displayed as can be seen from above descriptive statistic of the data above. No big ranges and malicious data that can scare the econometric estimation of the data.

4.1.3. Correlation Matrix

Table 2. Correlation Matrix

Correlation	FDIU	FDIC	EXCU	GDPU
FDIU	1.000000			
FDIC	0.417064	1.000000		
EXCU	0.640572	0.316282	1.000000	
GDPU	-0.238524	-0.318128	-0.056947	1.000000

Note: Covariance analysis (Ordinary) for 35 observations from 1982 to 2016

The correlation matrix above shows the magnitude and direction of the relation among variables. There is a close positive correlation between FDIu and FDIc with correlation coefficient of 0.42. This suggests the presence of conflict (riverlness) in FDI outflows between US and China.

4.2. Time Series Properties of the Data

This section presents the Engle-Granger 2-steps procedure test.

4.2.1. Unit Root Test

This section pre-test the variables to check the order of integration by using ADF unit root test both at level and at first difference. The table below presents the stationarity test results of the unit root test.

Table 3. Unit root test results

ADF (Intercept)

Variable	At Level	At 1st Difference
FDIU	0.1029	0.0000*
FDIC	0.2920	0.0000*
EXCU	0.9143	0.0004*
GDPU	0.8064	0.0000*

Note: * shows significance at 1 percent percent level.

All variables are I(1), meaning that they are integrated of order one (at first difference).

4.2.2. Cointegration Test

This test provides evidence of the presence of long-run relationship between variables since the variables are of I(1). We first estimate the model eq01) and then save residuals (resid01). The residuals are then tested for unit root at levels using ADF test with no intercept. The results are displayed below:

Table 4. Regression Output of the Long-run Relationship

Dependent Variable LFDIu

Independent variables	Coefficient	Standard Error	t-statistic
LFDIc	(0.286588)**	0.127063	2.255480
EXcu	(0.220703)*	0.053607	4.117077
GDPu	(-0.090585)***	0.047315	-1.914532
Constant	(-0.726343)***	0.0419015	-1.738227
R^2	64%		
Adjusted R^2	61%		
F – Statistics	17.81		
DW Statistics	2.15		

Notice that *FDIu* and *FDIc* variables are expressed in natural logarithms (*LFDIu* and *LFDIc* respectively), while *GDPu* variable is expressed in difference form (*DGDPu*). These adjustments to the variables were necessary for significant results. The residuals (resid01) from this output were then tested for cointegration as seen in the results below. The residual was also tested for unit root and was found to have no unit root, hence the series are indeed cointegrated.

4.3. The Estimated Model

This section provides an estimation of the model in equation 4. We provide a standard formal representation of the model whose output is shown in table 4 above.

LFDIU = -0.73 + 0.29LFDIC + 0.22EXCU - 0.09DGDPU

std err. [0.42] [0.13] [0.05] [0.04]

t stat. (-1.7) (2.3) (4.1) (-1.9)

n = 34, R^2 = 0.6404, Adjusted (R^2) = 0.6045

The results above shows that the paper involved 34 time series observation after adjustments. As shown by the R^2, explanatory variables explain the dependent variable by about 64%, other things held constant. *LFDIc* and *EXcu* are significant at 5% and 1% levels, respectively while *DGDPu* is significant at 10% level. Other things being constant, FDI outflows in US increases by 0.29% for every additional increase of one percent of FDI outflows in China. On the other hand, a one percentage point increase in exchange rate between US and China increases FDI outflows in US by about 0.0022% ceteris paribus. The annual percent rate of GDP in US and the FDI outflows in US move in opposite direction. Ceteris paribus, a one percent decrease in GDP in US increases FDI outflows in US by 0.0009%.

4.4. Statistical and Econometrics Test

The post estimation of this paper involved serial correlation test, specification error test, stability test, multicollinearity test and causality test. Eq01 was used in all these tests.

Serial Correlation Test

Despite the fact that the Durbun-Watson (DW) statistic is greater than 2 (*eq01*) which suggests absence of serial correlation, it was important to take advanced test. The serial correlation LM test with 2 lags was done and the results are shown in the table below.

Figure 2. Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test			
F - Statistic	0.334623	Prob. F(2,28)	0.7184
Obs*R-squared	0.793686	Prob. Chi-Square(2)	0.6724

The results suggest absence of serial correlation in the data set used in this paper. The *p valu*e Chi-square is greater than 0.05 (0.67) and therefore the null hypothesis of no serial correlation is retained.

Ramsey RESET Test

This tests regression specification error in the model. The Ramsey RESET test results are displayed below.

	Value	**df**	**Probability**
t-statistic	1.522066	29	0.1388
F-statistic	2.316685	(1, 29)	0.1388
Likelihood ratio	2.613077	1	0.1060

The results show that no specification error in the model. The F-Statistics measured by the p-value of 0.14 (which is greater than 0.05) is not significant, hence we fail to reject the null hypothesis of no specification error.

Stability Test

Stability of the dependent variable was tested to check its credibility. CUSUM test was done and the results indicated that FDIu is a stable and credible dependent variable since the CUSUM lies within the 5% significance levels. The model was also tested for multicollinearity and it was not seen as a problem since the centered variance inflation factors (VIF) are less than 10. The causality test, on the other hand suggests that FDIc strongly causes FDIu and not otherwise as proved by Pairwise Granger Causality Tests.

5. Conclusions

In this paper we studied a game theory application to the United States and China FDI outflows by analyzing the Cournot model of static and complete information. Game theory involves the study of the ways in which strategic interactions among rational players produce optimal outcomes with respect to the preferences (or utilities) of those players (Chin-Hao, 2007). According to Gibbons (1992), static game means a simultaneous-move game as opposed to dynamic game which involves sequential-move. And complete information means player's payoff function is common knowledge among all players as opposed to incomplete information where a player is uncertain about another player's payoff function. All these assumptions of static and complete information apply to our case of US and China. The choice and supply of FDI outflows in US and China is done simultaneously and that both countries have complete information on the profit of FDI outflows.

In section 3 of this paper we described a game between US and China in the Cournot model setting. Section 4 we solved the theoretic-game problem between the countries about FDI outflows. In this section we present the results of the game in a bi-matrix form and apply iteration elimination of strictly dominated strategy to solve for the Nash equilibrium which survives iteration elimination of strictly dominated strategy to produce a unique prediction/solution to the battle for FDI outflows between US and China.

A: Normal-Form Representation of the FDI outflows Game

Players – involves the two countries, US and China

Strategies – Supply or Not Supply FDIs, for each country

Payoff – quantities of FDI supplied by each country

B: Solving the Game-theoretic problem empirically

The assumption is that a rational player (US and China) will not play a strictly dominated strategy. Consider the following bi-matrix below which is constructed using empirical estimation of equation *6* of this paper.

$$LFDIU = -0.73 + 0.29LFDIC + 0.22EXCU - 0.09DGDPU$$

Since our study is on *FDIu* and *FDIc* then we ignore *EXcu* and *DGDPu* for simplicity to be able to present and analyze the game-theoretic problem of our case. Hence the resulting equation becomes,

$$LFDIU = -0.73 + 0.29LFDIC$$

Ceteris paribus, for every 1% FDI outflow supplied by China, US supplies 0.3% of FDI outflow. If China decides not to supply, then US will supply -0.7. If US decide not to supply then China will supply 2.5 (0.73/0.29). Lastly, if both countries decide not to supply then they will all end up with 0. The results are presented in the bi-matrix below;

		CHINA	
	XXXXXXXXXXXXXX	Supply FDI (%)	Not Supply FDI (%)
US	Supply FDI (%)	**0.3, 1**	**-0.7, 0**
	Not Supply FDI (%)	**0, 2.5**	**0, 0**

From the table above, if China plays Supply strategy then US will also play Supply because 0.3>0. If China plays Not Supply strategy then US will play Not Supply because 0>-0.7. On the other hand, if US plays Supply strategy then China will play Supply because 1>0, and lastly, if US plays Not Supply strategy then China will play Supply since 2.5>0. Therefore, the (Supply, Supply) strategy combination becomes the Nash equilibrium since it is unique and no country has incentive to deviate from it. However, if US and China decide to cooperate and have mutual trust then they can create the maximum total benefit from FDI outflows. Equation *3* of this paper shows this possibility in our case. This equation *3* presents the total equilibrium quantity of FDI outflows to be gained if the countries decide to cooperate.

$$q_C^* = q_u^* = \left|\frac{a-c}{3}\right|$$

From the estimation of equation *4*, a=-0.73, c represents the marginal cost, which is assumed to be constant by the Cournot model. Since exchange rate (EXcu) represents the cost of FDI outflows then its coefficient must represent the marginal cost, and it is indeed constant. Therefore, c=0.22. Substituting these values yields;

$$q_C^* = q_u^* = \left|\frac{-0.73-0.22}{3}\right| = 0.32$$

Therefore, both countries will jointly supply 32% of the total FDI outflows and enjoy the maximum profit.

The main conclusion is that, in a static situation with complete information, optimal equilibrium is established if US and China produces 0.3% and 1% of FDI outflows respectively. This is a conflict solving solution to the battle/riverlness on FDI outflows between these countries if they decide not to cooperate. However, if both countries decide to cooperate then they will monopolize the FDI outflows market by 32% and maximize the total gains.

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