The Gravity Model and Sunk Costs: A Theoretical Analysis

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August 26, 2005

Abstract

Dixit (1989), Eichengreen & Irwin (1996), Anderson & Marcouiller (1999) and Das et. al. (2001) showed the determining presence of Sunk Costs in the model of bilateral trade. Using this literature, some economists have introduced the trade lagged variable in the model.

Nevertheless, in determination of the trade model, it is expected that the economic agent's expectations are more important than the trade lagged variable. In addition, these expectations are possible to be included in the bilateral trade model by considering the presence of sunk costs.

In this paper, we develop the model of Anderson and Wincoop (2003) to a theoretical gravity model which takes into account the expected trade costs to determine the volume of bilateral trade. This new theoretical development allows the participation of the expectations in determination of the trade model. To study empirically the effects of expected trade costs on the model, we also suggest a method for estimating the future growth rate of bilateral trade costs.

Moreover, our theoretical model makes it possible to justify the presence of some variables usually used in the gravity models. On the other hand, the ignorance of expectations could lead to a wrong interpretation of the coefficients of these variables.

Acknowledgement 1 *During these last years, I was pleased to work on my thesis under the direction of Mr. Nicolas Péridy. I would like to thank him, especially for his useful comments and suggestions in this paper.*

1 *Introduction*

The theoretical bases of the gravity model specifies the relationship between variables of the model and theories of international trade. The studies (Deardorff (1998) and Evenett and Keller (2002)) show that the gravity model is explained by the various theories of international trade. In recent years, some new theoretical developments, particularly the studies of Anderson and Wincoop (2003) and Deardorff (2004), have established the gravity model by considering the important role of the relative costs of trade.[1] However, these gravity models take into account only current trade costs to determine the model of the bilateral trade.

There are also various sunk costs related to trade flows. Ansic and Pugh (1999), Bernard and Jensen (2001), Freund and Keller (2002), Roberts and Tybout (1995) showed that these costs considerably affect the enterprise decisions on exports. Moreover, Dixit (1989), Sutton (1991), Eichengreen and Irwin (1996), Anderson and Marcouiller (1999) and Das et. al. (2001) showed theoretically the determining presence of sunk costs in bilateral trade. Using this literature, certain economists have introduced the lagged variable of trade into the gravity model. Nevertheless, the presence of the sunk costs makes it possible to introduce the expectations of the economic agents as the explicit determinant of the bilateral trade in the model.

[1] See also: Hummels (2001) and Leamer and Levinsohn (1995) and Deardorff (2005) who also insist on the role of the trade costs in the determination of the trade model.

For the enterprise, the exit from market is expensive because there are some irrecoverable costs. In this case, the enterprise desires a presence on the market during which the sunk costs are absorbed (amortized). It also wants a satisfactory profitability for its activities in this period. Then, in the presence of sunk costs, it predicts the future conditions of its trade flows with other countries. These expectations strongly matter to its present volume of trade. However, the gravity model does not take the expectations into account in the determination of bilateral trade model.

In this paper, we introduce the expectations term into the gravity model. The new theoretical development modifies the term of comparative advantages of trade already established by Anderson and Wincoop (2003). The new gravity model deduced from such a development can better explain empirical observations related to some variables usually used in gravity models.[2] Moreover, in this paper, we propose some empirical methods for introducing the expectations term into the gravity model.

The following section shows the presence of sunk costs in bilateral trade. Section 3, which is the principal section of the paper, presents the relationship between sunk costs and the gravity model and consists of two sub-sections. In the first (3.1), we present the existing interpretation of the effects of sunk costs on the model of bilateral trade. This interpretation introduces the lagged variable of trade into the gravity model. In the second sub-section (3.2) we develop the relationship between expectations and the presence of sunk costs in the gravity model. Moreover, we present the microeconomics basis which shows the expectations' importance in the enterprise's decision-making when there are some sunk costs in bilateral trade. Next, bearing in mind the model of Anderson and Wincoop (2003), we present a new gravity model which takes into account the expectations term in determining the bilateral trade model. Section 4 shows an empirical method which allows introducing the expectations term into the gravity model. Section 5 presents a new explanation for the impacts of monetary

[2]International economists try to capture the effects of economic agreements, cultural relations, common border and common economic history of two countries on bilateral trade by using the various variables added to the gravity model: Aitken (1973), Bergstrand (1985), Thursby and Thursby (1987), Filippini and Molini (2003), Maurel (2004), De Benedictis and Vicarelli (2004), Okubo (2004), Péridy (2005).

unification on bilateral trade. Finally, section 6 summarizes the conclusions of the paper.

2 *Sunk Costs in bilateral trade*

The sunk costs are a part of costs related to bilateral trade. The variable of trade costs (particularly transport cost) is one of the old variables of the gravity models. In economic sciences, the sunk costs are those which were already incurred and cannot be recovered in an important way. Owen and Ulph (2002) indicated that the third generation of the theories of international trade confirms the importance of the costs of access to the market some of which are sunk costs.

In a business context, an enterprise in order to export towards a new market needs to have the necessary technology, know the foreign market, learn the administrative procedures of the country, find the collaborators in that country, redesign the line of production and packaging of goods and advertise for its offers in order to compete with the other enterprises. Sometimes it is important to reorganize its staff, create new services, invest in particular equipment or establishment which is not easily used for other purposes. Usually, the expenditure of the enterprise for such needs constitutes its sunk costs. Then, if the enterprise stops its activity on such a market in the future, it will lose a great part of the value (benefit) of this expenditure. Similarly, an importer may support the sunk costs in order to provide and supply the foreign goods in the domestic market. Indeed, he concentrates on specific foreign trade marks and tries to improve their position in the domestic market. Thus, for such an importer, there are sunk costs for changing the composition of its basket of goods. .

From the middle of the Eighties, the international economists have paid attention to the sunk costs in the theory of the international trade. Dixit (1989) is one of the first economists in this context. He shows that in the presence of sunk costs the marshallian conditions for the presence of the enterprise in the market will be:

$$P_H > W + \rho K \equiv W_H \quad (1)$$

$$P_L < W - \rho L \equiv W_L \quad (2)$$

where P_H, P_L respectively are the prices according to which the enterprise decides to enter and to leave the market. K presents the investments on the sunk costs and L represents the costs of the enterprise if it leaves the market. Moreover, ρ is the interest rate related to investment. So, if K and L tend towards zero, P_H and P_L tend towards the same point W. By this, Dixit indicated that in the presence of the sunk costs, the enterprise requests a higher price than its marginal cost of production to enter the market. However after the entrance, it will stay in the market even by supporting a net loss of operation in order to avoid L and K. Therefore, the initial decision of the enterprise to export towards a market influences its current activities. Indeed, the enterprise which has already appeared in a market tends to remain there during the following period because it has already paid a part of its maintenance costs in the market. This has led international economists to take into account the lagged variable of trade in order to determine the bilateral trade model.

We present the models of gravity deduced from such a theory in the following section. There, we develop another possible relationship between the sunk costs and the gravity model. An enterprise is an entity trying to maximize the current value of its projects while the sunk costs make its decisions inflexible. Therefore, in the presence of these costs, it tries to predict the future flow of its profits to determine the current and relative value of its project. It tries to make decisions with less change in the future because each change brings about additional costs. In this step, it takes into account the information which explains the future levels of demand, price and bilateral trade costs. In other words, the economic agents' expectations on the future conditions of their trade are important in determining export destinations of the enterprise. Using these information, the enterprise tries to avoid unfavorable (detrimental) future engagements. We demonstrate that the existence of the sunk costs justifies introduction of expectations into the model of trade and therefore into the gravity model. This argument proves the important role of the future in determining the behavior of exporters and importers and also the bilateral trade model.

3 *Sunk Costs and the Gravity Modeling of Bilateral Trade*

3.1 Sunk costs and the lagged variable of trade

As mentioned previously, some studies of international trade have examined the effects of the sunk costs on bilateral trade by the introduction of the lagged variable into the model. Indeed, Campa (2004) proved the presence of the sunk costs by the existence of the significant difference between the coefficient of the lagged variable of the trade and the zero value. Therefore, the literature of international trade considers the effects of the sunk costs on trade only in the form of the effects of past on present. Other examples such as Filippini and Molini (2003) and Bun and Klaassen (2002) presented their empirical gravity models by introducing the lagged variable of the trade as one of the explanatory variables of the model. Bun and Klaassen (2002) confirmed that a dynamic gravity model (increased by the lagged variable of trade) can predict the bilateral trade better than a static model. They estimate the following model by using the panel data :

$$Trade_{ijt} = \alpha + \sum_{p=1}^{2} \gamma_p Trade_{ij,t-p} + \sum_{q=0}^{2} \beta_q GDP_{ij,t-q} + \eta_{ij} + \lambda_t + \varepsilon_{ijt} \tag{3}$$

where γ_p and β_q respectively represent the effects of the lagged variables of trade and GNP for the periods p and q on the volume of the bilateral trade. η_{ij} represents the fixed effects between partners i and j and λ_t captures the effects of time t. According to the model (3) the volume of the bilateral trade depends on the value of the lagged variable of trade and that of GNP during several previous periods. The estimations show that the dynamic model produces a higher R^2. Moreover, the coefficient of $Trade_{ij,t-1}$ presents the important effects of the lagged variable on bilateral trade. The same conclusions were obtained by Benedictis and Vicarelli (2004) and Péridy (2005) who showed that the difference between the potential and real trade decreases when one employs the dynamic gravity model instead of the static model. It means that the dynamic gravity model provides better predictions for bilateral trade flows. Taking into account such results, Bun & Klaassen (2002), Benedictis & Vicarelli (2004) and Eichengreen & Irwin (1996) indicated that the ignorance of hysteresis leads to a wrong interpretation of the gravity model. They showed that in this case, the coefficients of some variables like the dummy variable of the free trade agreement and that of the fixed effects of the partner countries can be incorrectly interpreted.

Yet, we demonstrate that the effects of the sunk costs on the trade model can be explained in another way. Indeed, the presence of sunk costs results in growth of the role of the expectations of the economic agents in the international trade model. In the following subsection we will develop this idea.

3.2 A new interpretation of the sunk costs for the gravity model of trade

3.2.1 Microeconomics context

The second possible development for the gravity model, because of the presence of the sunk costs, is the introduction of economic agents' expectations into the gravity model as one of the determinants of the bilateral trade model. Although the microeconomics basis of the relationship between sunk costs and expectations have been established, the gravity models do not take into account the expectations to explain the volume of bilateral trade.

Das et. al. (2001), Roberts & Tybout (1997), Tybout (2001) and Campa (2004) developed theoretical models of the entry and the exit of firm from the market with the existence of sunk costs. Because of the similarity between their modelings, we present only the model developed by Roberts & Tybout (1997). In addition, we assume that the firm can choose the destination of its exports among various foreign markets K. The profit of the firm i for the period T is defined as follows:

$$R_{itk}(Y_{itk}^{(-)}) = Y_{itk}[\pi_{itk} - F_{ik}^{0}(1 - Y_{ik,t-1}) - \Sigma_{j=2}^{J_i}(F_{ik}^{j} - F_{ik}^{0})\tilde{Y}_{ik,t-j}] - X_{ik}Y_{ik,t-1}(1 - Y_{ikt}) \quad (4)$$

where $Y_{itk}^{(-)}$ represents the history of enterprise i at the period T for the market k, and $Y_{itk}^{(-)} = \{Y_{ik,t-j} \mid j = 0, ..., J_{ik}\}$ when J_{ik} is the age of the firm. π_{itk} is the profit flow of the firm without costs of exit and entry to the market. F_{ik}^{j} represents the costs of the firm to reenter the market k on the condition that it had exported at the period $t-j$ $(j \geqslant 2)$. But if the firm never exported towards the market k, it is confronted with the cost F_{ik}^{0} to enter the market. X_{ik} is the costs with which the firm is confronted if it leaves the market and Y_{itk} takes value 1 if the firm exports on the market at the period t and value 0 if not. Lastly, $\tilde{Y}_{ik,t-j} = (Y_{ik,t-j}\Pi_{l=1}^{j-1}(1 - Y_{ik,t-l}))$. Indeed, according to the expression (4), the former participation of the firm in the market affects the current level of its profits. However, the firm decides the participation in the market k for maximizing the total current value of its export projects:

$$V_{it}(\Omega_{it}) = \max_{Y_{it}^{(+)}} E_t(\Sigma_{j=t}^{\infty}\Sigma_k \delta^{j-t} R_{ijk} \mid \Omega_{it}) \quad (5)$$

where δ is the one-period discount rate. E_t denotes the expected values conditioned on the information set Ω_{it}. The following suggestions result from the formula (5):

1- Expectations of the firm about the future trade conditions have an important role for the participation of the firm in the market k.

2- Macroeconomic events and trade policies affect directly (by R_{ijk} and δ^{j-t}) and indirectly (by Ω_{it} and forming the expectations) the participation of the firm in the foreign market.

Roberts & Tybout presented the participation condition of the firm in the market by:

$$\begin{aligned} \pi_{it}^{*} &= \pi_i(P_t, S_{it}) + \\ & \quad \delta[E_t\left(V_{i,t+1}\left(\Omega_{i,t+1}\right) \mid Y_{it}=1\right) - E_t\left(V_{i,t+1}\left(\Omega_{i,t+1}\right) \mid Y_{it}=0\right)] \\ &\geqslant F_i^0 - \left(F_i^0 + X_i\right) Y_{i,t-1} - \Sigma_{j=2}^{J_1}\left(F_i^0 - F_i^j\right) Y_{i,t-j} \end{aligned} \tag{6}$$

where F_i^0 represent the total sunk entry costs of the firms that have never exported to the market, X_i denotes the exit costs of current exporters. P_t is the vector of market-level forcing variables that the firm takes as exogenous variables. S_{it} is the vector of state variables specific to the firm (e.g., capital stocks and geographical location). If there are no sunk cost, the participation condition of the firm summarizes to: $\pi_i(P_t, S_{it}) \geqslant 0$. In other words, in absence of sunk costs, the firm considers only the current profitability level in order to decide about exporting to the market. In such a case, neither its former participation, nor its future prospects affect its entry or exit decisions from the market. However, in the presence of sunk costs, the expression $\delta\left[E_t\left(V_{i,t+1}\left(\Omega_{i,t+1}\right) \mid Y_{it}=1\right) - E_t\left(V_{i,t+1}\left(\Omega_{i,t+1}\right) \mid Y_{it}=0\right)\right]$ shows the attention of the firm to future profit flows. Indeed, the firm is interested in the quantity and the probability of the future profits. These expectations are determined by macroeconomic conditions and trade policies.

Tybout (2001) developed in the same way the model of participation of the firm in the market. This model presents the following equation:

$$
\begin{aligned}
V\left(e_t, x_{it}, c_{it}, \varepsilon_{it}, y_{it-1}\right) \quad = & \\
& \max\{\pi^f\left(e_t, x_{it}, c_{it}\right) - \left(1 - y_{it-1}\right)\Gamma_s \\
& + \varepsilon_{it} + \delta E_t V\left(e_{t+1}, x_{it+1}, c_{it+1}, \varepsilon_{it+1}, y_{it}\right)\} y_{it} \qquad (7)
\end{aligned}
$$

where Γ_s is the sum of the entry costs for a new exporter and ε_{it} defines serially uncorrelated noise. Moreover, Tybout showed that expectations of exporting firms influence the model by e_t,x_{it} and c_{it} which represent respectively the exchange rate, the foreign demand shifter and the marginal production costs.

3.2.2 Gravity modeling

The microeconomics context cited above shows that in the presence of sunk costs, the economic agents' expectations affect the trade model. Nevertheless, the current gravity models study the effects of the sunk costs on trade only under the role of the lagged variable of trade in the model. Although the estimated models show an important relationship between the lagged variable of trade and the current volume of the bilateral trade, we present below some critical comments relating to this interpretation of the effects of the sunk costs:

1- Trade anteriority cannot explain the primary firms' decisions about entering into a market. Let us consider the case where trade between two countries is not strong. If the prospects for bilateral trade are positive, these countries will trade with each other, even in absence of trade anteriority. Indeed, the lagged variable of trade in the gravity model represents the previous economic agents' expectations about bilateral trade flows. The introduction of the lagged variable into the gravity model can lead us to a wrong interpretation of the bilateral trade determinants, if one does not know the expectations role in bilateral trade.

2- Hystereses are not an obligatory trade condition if the formula (6) is not respected. Indeed, if there is no positive prospect, the firm will leave the foreign market in spite of its former participation.

3- Bun & Klaassen (2002) and Roberts & Tybout (1997) showed that the relationship between the lagged variable and the volume of trade decreases strongly from the second period ($Trade_{ij,t-2}$). This fact shows that anteriority is not a permanent condition to determine the trade model.

During its presence in a foreign market, the enterprise is always confronted with some sunk costs, such as advertising costs.[3] Indeed, it is suitable to consider the flows of sunk costs instead of the only sunk entry costs. In this case, the enterprise desires a duration of operation during which it can benefit from the advantages of its investment on sunk costs. This fact makes it possible to introduce the expectations term as one of the determinants of the bilateral trade. Thus it is obvious that the enterprise tries to predict the future consequences of its presence in the market. Indeed, the duration of amortization of enterprise's sunk costs defines the enterprise's engagement in the market. The equation (8) shows the average period of the amortization of the sunk costs:

$$\bar{D}_{it} = \frac{\sum_{j=1}^{n} D_{jt} C_j}{\sum_{j=1}^{n} C_j} \tag{8}$$

where C_j denotes the enterprise's sunk costs related to the project j carried out on the market. D_{jt} is the remaining lifespan of the project j at the time t and n is the number of the projects carried out by the enterprise i. Then, the enterprise tries to predict the events that determine its next costs and incomes during the time $\bar{D}_{it}$ in which it is confronted with a number of sunk costs. In other words, the period $\bar{D}_{it}$ shows the duration whose costs and incomes are taken into account by the enterprise in order to decide to enter, remain

[3] The sunk costs as fixed costs are amortized through time. For example, the effects of an advertising program can last more or less than a year.

or leave the market. In addition, this period cannot be infinite because the uncertainty of expectations increases for the future periods.

In the presence of its sunk costs, it is expensive for the enterprise to leave the market before the period $\bar{D}_{it}$. However, it is obvious that if the net expected loss by staying in the market is higher than the costs of leaving it, the enterprise will leave the market in spite of its irrecoverable expenditures:

$$Y_{it} = \begin{cases} 1 & \text{if } \pi^*_{it} - F_i^0 + \left(F_i^0 + X_i\right) Y_{i,t-1} + \Sigma_{j=2}^{J_i} \left(F_i^0 - F_i^j\right) Y_{i,t-j} \geqslant 0 \\ 0 & \text{otherwise} \end{cases} \tag{9}$$

where $Y_{it} = 1$ indicates the participation of enterprise i in the market at the period t.

Thus in spite of the relative engagement of the enterprise to its history in the market, the enterprise's outlooks for the future trade conditions determine the trade model of the enterprise on the market.

Under the new interpretation of the sunk costs role, the gravity model takes into account the expectations term to determine the bilateral trade model. Throughout the rest of this section, we will develop the gravity model of Anderson and Wincoop (2003, 2004) by the expectations term.

Anderson and Wincoop presented the gravity model below:

$$x_{ij} = \frac{y_i y_j}{y^w} \left(\frac{t_{ij}}{P_i P_j} \right)^{1-\sigma} \tag{10}$$

where x_{ij} is the exports value of country i towards the country j when y_i, y_j and y^w respectively represent the incomes of country i, j and the world. σ displays the substitution elasticity between goods. t_{ij} is the trade costs factor between i and j. P_i and P_j are respectively multilateral resistances of country i and the country j vis-a-vis their trade with other countries. In the formula above, Anderson and Wincoop considered that the trade barriers were symmetrical, $t_{ij=}t_{ji}$.

According to this model, the bilateral trade volume depends on the relative trade costs of i and j in comparison with their trade costs with the other partners. Indeed, countries i and j will continue their bilateral trade if the trade between them carries some cost advantages vis-a-vis the same trade with other countries.

We introduce into the model (10) the expectations term for the bilateral trade between i and j. In addition, this term is relative vis-a-vis the expectations related to the other trade flows of i and j. Indeed, we modify the comparative advantages term which appeared in the model (10) by presenting the term of *expected comparative advantages*. The obtained gravity model is:

$$T_{ijt} = \frac{y_{it}y_{jt}}{y_t^w}\left[\left(\frac{t_{ijt}}{P_{it}P_{jt}}\right)^{1-\sigma} \underset{t=0}{\overset{T}{E}}_{ijt} \mid \Omega_t\right] \tag{11}$$

where the index t shows the time periods and the term E_{ijt} represents the vector of economic agents' expectations on the profits of future bilateral trade flows between i and j and from the present to T. Ω_t denotes the information vector at the period t. This vector includes the information that matter to the bilateral trade model. T is the duration during which the enterprise is confronted with some sunk costs. This duration can be equivalent to $\bar{D}_{it}$ presented above. *In fact, in the model (11), by the term E_{ijt}, expectations modify (redefine) the comparative advantages related to the trade between i and j. Indeed, the expression* $\left[\left(\frac{t_{ijt}}{P_{it}P_{jt}}\right)^{1-\sigma} \underset{t=0}{\overset{T}{E}}_{ijt} \mid \Omega_t\right]$ *presents "the expected trade comparative advantages" between i and j.*

The term E_{ijt} denotes the expectations on different parameters such as the demand, the supply and the trade policies in the partner countries. Nevertheless, the recent theoretical literature concerning international trade considers the role of the effects of trade costs as relatively important. In this direction, we take again the model of Anderson and Wincoop (2003, 2004) and modify the relative term of trade costs by introducing the expectations about the relative costs of future trade flows at period t:

$$T_{ijt} = \frac{y_{it} y_{jt}}{y_t^w} \left(\frac{t_{ijt}^{eT}}{P_{it}^e P_{jt}^e} \right)^{1-\sigma} \tag{12}$$

where t_{ijt}^{eT} represents the current average value of the expected trade costs between i and j for the period from the present to T. In other words, t_{ijt}^{eT} is defined in the following way:

$$t_{ijt}^{eT} = \frac{t_{ijt} + \sum_{k=1}^{T} \left(1 + \beta_{t+k}^e \mid \Omega_t\right) t_{ijt} \delta^k}{T} \tag{13}$$

where β_{t+k}^e is the net growth rate of expected trade costs between i and j at the period $t+k$ (see the appendix A) and δ^k represents the discount rate corresponding to k next periods. As $\beta_t^e = \beta_t$ we can rewrite the formula (13) as:

$$t_{ijt}^{eT} = \frac{\sum_{k=0}^{T} \left(1 + \beta_{t+k}^e \mid \Omega_t\right) t_{ijt} \delta^k}{T} \tag{14}$$

Similarly, P_{it}^e and P_{jt}^e show the current average values of the expected multilateral trade barriers related to the trade of i and j with the other countries during the same period T.

Contrary to the model of Anderson and Wincoop which takes into account only the present (current) trade costs, the model (12) determines the volume of bilateral trade by considering the role of economic agents' expectations concerning the various trade flows with the candidate countries.

The expectations are invisible factors and difficult to estimate. However in the following section we will present a method that an economic agent could employ to evaluate the invisible part of the formula (13), β_{t+k}^e. In effect, we assume that the economic agent considers a regression relationship between β_t and several explanatory variables at the period t. The explanatory variables are the factors that affect the level of trade costs and determine the value of β.

4 *The gravity model: Estimation of the Expectations (an empirical point of view)*

The theoretical model (12) presents the trade comparative advantages between i and j according to their expected relative trade costs. In this case, the expectations participate in the trade model determination through the gravity model. In order to transform the model (12) to an estimable gravity model, we need to estimate the expected relative costs of trade between i and j defined by the formulas (13) or (14). For convenience, we rewrite the formula (13):

$$t_{ijt}^{eT} = \frac{t_{ijt} + \sum_{k=1}^{T} \left(1 + \beta_{t+k}^{e} \mid \Omega_t\right) t_{ijt}\delta^{k}}{T} \tag{13}$$

To estimate the term t_{ijt}^{eT} we need only to estimate T and β_{t+k}^{e}[4]. In the previous section, we explained how T is determined. Indeed, T represents the period whose costs and incomes are considered by the economic agents. As mentioned already, this period corresponds to the duration in which the economic agents are confronted with a number of sunk costs. Additionally, the purpose of this sub-section is to show the estimation method of β^{e} for the period $t+k$. Then, the important question of this part of the paper is: how the value of β^{e} is to be evaluated by economic agents?

In fact, at the period t, the information set of economic agent is Ω_t. Ω_t includes the information concerning the bilateral trade between i and j. To predict β_{t+k}, the economic agent also needs an economic model. This model uses the past observations to estimate the coefficients of various variables which affect the growth rate of trade costs.[5]

[4]Instead of the estimate of β_{t+k}^{e}, the economic agent can also estimate α whose relation with β_{t+k}^{e} is explained in appendix A.

[5]In fact, according to economic methodology, the relation between the dependent variable and the explanatory variables in the model should be confirmed by the economic theory. This suggests an economic model whose predictions will be rational. For more information, see: Broze et al.. (1990), Minford (1992) and Sheffrin (1996).

Tariffs, transport costs, administration costs, profit margins of the businessmen, advertising, costs related to the knowledge of the foreign market and insurance are various costs of the enterprise in order to export towards foreign markets.[6] In this case, the factors that change the level of these costs are the explanatory variables for the model determining the growth rate of trade costs. For example, the dummy variables of free trade agreement and monetary unification can be considered as the explanatory variables of such a model. Because these agreements decrease the bilateral trade costs.

The estimation technology of β^e_{t+1} is composed of three steps. Firstly, the economic agent supposes various estimation models for β^e_{t+1}. According to his hypothesis, some variables can be different between the different models. Then, the economic agent estimates the various models developed at the previous step by using panel data. And finally, he chooses the best model to estimate β^e_{t+1} by the criterion of R^2.

The following formula defines K models supposed by the economic agent at the first step:[7]

$$\beta^k_{ij,t} = \alpha^k_0 + \sum_{m=1}^{M} \alpha^{km} \sigma^{km}_{ij,t} + \sum_{n=1}^{N} \gamma^{kn} \delta^{kn}_{i,t} + \sum_{P=1}^{P} \lambda^{kp} \nu^{kp}_{j,t} + \varepsilon^k_{ij,t} \qquad k = 1, ...K \tag{15}$$

where α^k_0 is the fixed factor of the model k, $\sigma^{km}_{ij,t}$ represents the m th explanatory variable of the model k which shows the existence of a common factor between i and j at the period t. This factor (for example: a FTA between i and j) affects the level of trade costs between i and j. $\delta^{kn}_{i,t}$ is n th explanatory variable of the model k which represents a character of country i at the period t. This character (for example: the quality of the transportation and communication systems of the country i) matters to the trade costs between i and j. Similarly, $\nu^{kp}_{j,t}$ shows p th explanatory variable of the model k which denotes a character of

[6] Sometimes some of these costs are discriminatory for a foreign company. For example, in certain countries the advertising cost for the foreign products is higher than the advertising cost for the domestic goods. Moreover, some studies show that the trade between two close countries is less strong than the trade between the provinces of the each country. These effects (the border effects) exist because of the presence of confidence, habits and social advantages existing in the internal trade flows. In this case, a foreign company should find a solution to eliminate these barriers and then the trade costs level for a foreign company is higher.

[7] We also presented these equations in the matrix form in the appendix B.

the country j at the period t. Finally, $\varepsilon_{ij,t}^{k}$ represents the error term of the model k.

After defining the explanatory variables, one can estimate the models above by an estimator like OLS. The model which represents highest R^2 is regarded as the best model to estimate β for the following period (β_{t+1}^{e}).[8]

Indeed, the economic agent estimates β_{t+1}^{e} through such a model by introducing the expected values for the explanatory variables of the model at the period $t+1$. Similarly, it can predict β for several following periods.

A direct introduction of the expectations term β_{t+k}^{e} $(k = 1, ..., T)$ or an indirect introduction of this term by the introduction of t_{ijt}^{eT}, P_{it}^{e} and P_{jt}^{e} in the gravity model largely allows expectations playing an important role in the empirical determination of the bilateral trade flows through the gravity model. In this case, we expect the negative signs for the coefficients of β_{t+k}^{e} and t_{ijt}^{eT} and the positive signs for the coefficients of P_{it}^{e} and P_{jt}^{e} in the gravity model of trade between i and j.

The last section of this paper will show how expectations generate better explanations for the coefficients of some variables already used in the gravity models. Thereafter, we will study more precisely the monetary unification effects on the trade through its effects on economic agents' expectations.

[8]Some explanatory variables of the model like the quality of the road infrastructures do not change very much over a few years. In order that these variables present a significant variation from one period to another, one can consider t as a duration of several years, for example five years.

5 *An explanation for the effects of monetary union adhesion on bilateral trade: the case of the gravity model*

Rose (1999, 2000 and 2001) indicated that the monetary union adhesion matters to the bilateral trade model: on one hand by comparing the trade flows of the countries belonging to a monetary union with the trade flows of the countries outside of the union and on the other hand by comparing the trade flows of the countries before and after the monetary union.[9] By using the 186 countries database, the estimated gravity model by Rose (1999, 2000) showed that after a monetary union the trade volume between two countries is multiplied by three. Moreover, Rose (2001) developed a gravity model using the panel data of 217 countries for the period between 1948 and 1997. In this study, he found that the trade volume between the countries which leave the monetary union drops significantly. In addition, Rose estimated that the countries using the same currency doubled their bilateral trade.

In fact, Rose is not the only economist who shows the important effects of the monetary union on the trade model. Using a study based on "Meta-analysis"[10], Rose (2004), analyzed the results of 34 studies on this subject.[11] The analysis significantly refused the hypothesis of the absence of relationship between the common currency and the bilateral trade volume. Moreover from these studies, Rose deduced an important effect (between 30 and 90 percent) for a monetary union adhesion on the bilateral trade volume.

Why does the monetary union adhesion matter so strongly to the bilateral trade model? One of the explanations presented by the economists is that this adhesion decreases the trade risk because the fluctuations of exchange rate between two member states are eliminated. Consequently, the trade volume increases. However, Rose (1999, 2000) showed that the

[9] See also: Glick and Rose (2001) and Yeyati (2003).

[10] "Meta-analysis" is a sum of quantitative techniques that evaluates and transforms the different empirical results of various studies in order to provide a reliable result.

[11] For the list of the studies: Please, see table 5 in Rose (2004) using the gravity model on this subject.

suppression of fluctuations of the exchange rate was not the single source of such an effect. His model separately captures the effects of the fluctuations of the exchange rate by an independent variable ($V\left(e_{ij}\right)_t$), the dummy variable of adhesion:

$$\begin{aligned}\ln\left(X_{ijt}\right) &= \beta_0 + \beta_1 \ln\left(Y_iY_j\right)_t + \beta_2 \ln\left(Y_iY_j/Pop_iPop_j\right)_t + \beta_3 \ln D_{ij} + \beta_4 Cont_{ij} \\ &\quad + \beta_5 Lang_{ij} + \beta_6 FTA_{ijt} + \beta_7 ComNat_{ij} + \beta_8 ComCol_{ij} + \beta_9 Colony_{ij} \\ &\quad + \gamma CU_{ijt} + \delta V\left(e_{ij}\right)_t + \varepsilon_{ijt} \qquad (16)\end{aligned}$$

where i and j denote countries, t denotes time, and the variables are defined as: X_{ijt} denotes the value of bilateral trade between i and j, Y is real GDP, Pop is population, D_{ij} is the distance between i and j, $Cont_{ij}$ is a binary variable which is unity if i and j share a land border, $Lang_{ij}$ is a binary variable which is unity if i and j have a common official language, FTA_{ij} is a binary variable which is unity if i and j belong to the same regional trade agreement, $ComNat_{ij}$ is a binary variable which is unity if i and j are part of the same nation (e.g., France and its overseas departments), $ComCol_{ij}$ is a binary variable which is unity if i and j were colonies after 1945 with the same colonizer, $Colony_{ij}$ is a binary variable which is unity if i colonized j or vice versa, CU_{ijt} is a binary variable which is unity if i and j use the same currency at time t, $V\left(e_{ij}\right)_t$ is the volatility of the bilateral nominal exchange rate (between i and j) in the period before t, β is a vector of nuisance coefficients, and ε_{ij} represents the myriad other influences on bilateral exports that is assumed to be well-behaved.

Moreover, the models studied by the Meta-analysis capture separately the fixed effects of countries which could be carried by a variable like CU_{ij}. Therefore, the effects cited above for the monetary union adhesion show only the pure effects of this variable on the bilateral trade.

The other explanation for the monetary union effects on the bilateral trade shows that the monetary union reduces the transaction costs related to the exchange of currencies or price transparency in the member countries.[12] Although the fall of transaction costs increases the trade volume, the studies (De Sousa & Lochard (2004) and Semmler (2000), Buiter (1999), etc.) showed that these costs were not so important that they could affect the bilateral trade on such a scale.[13] Indeed, the current trade literature is not able to explain well the relationship between the bilateral trade and the monetary union adhesion. Rose (1999) and Anderson & van Wincoop (2004) indicated that in spite of the agreement between the international economists confirming the important effects of the monetary union on bilateral trade, the reasons for this influence are not clear.

On the other hand, the model (11) presents a new theoretical explanation for the presence of the dummy variable of monetary union in the gravity model. The effects of such a variable on the bilateral trade will be justified by *economic agents' expectations* which have been just refomed after the new agreement creating the single currency between two countries. According to the economic agents, the monetary unification means a great step towards the simplification and the expansion of the economic relationships between two countries. In this case, the enterprise has more chance to continue its trade flows in a profitable way. And thus the expression $\delta\left[E_t\left(V_{i,t+1}\left(\Omega_{i,t+1}\right) \mid Y_{it}=1\right)-E_t\left(V_{i,t+1}\left(\Omega_{i,t+1}\right) \mid Y_{it}=0\right)\right]$ in the formula (6) is defined so as to accept the trade sunk costs. Following the monetary unification, the economic agents expect a fall in tariffs between two countries, a harmonization of services and laws between them and decision-making favorable to the trade between two countries. In brief, they expect that the future bilateral trade costs are reduced following the formation of the monetary union between two countries. Therefore, the fall of transaction costs is not the only possible consequence of the creation of a monetary union. Indeed, the monetary unification not only decreases the transaction costs of trade and the currencies exchange

[12] See: De Sousa & Lochard (2004), Melnik & Nissim (2004), Semmler (2000), Buiter (1999) and Rose (1999).

[13] "Bank of International Settlement" estimates the savings of between 0.25 and 0.4 percent of the GNP for the member states of the European Currency Union by the decrease of the transaction costs. See also: Hallet (1998) and Buiter (1999).

costs, but also guarantees the regular profitability of future trade flows. This last fact matters strongly to the bilateral trade model through the expectations' effects.

The expectations can be influenced by other factors and information. The studies have shown that in particular the economic factors such as the exchange rate volatility, the trade agreements or the noneconomic factors such as political stability and safety can affect the expectations on trade.

In a study using the gravity model, Maurel (2004) showed that the exchange rate volatility produced negative effects on the bilateral trade volume. In the same way, Longo and Sekkat (2004) showed that internal political tensions strongly decrease bilateral trade. Moreover, the regional integration decreases the risk of political or military tensions and creates positive prospects on future bilateral trade flows. The study of Anderson and Marcouiller (1999) by the gravity model showed that the transparency and safety were important reasons for which the trade between rich countries was relatively high. Therefore, the absence of these variables in the gravity model (according to the case) generates the incorrect coefficients for the income variables of the model. Moreover, Anderson and Marcouiller indicated that the impact of the quality of the institutions on the trade volume was greater than those of tariffs. Through the expectations term, we established the gravity model (11) that yields better explanations for the effects of such variables.

6 *Conclusion*

The current theoretical bases of the gravity model do not present a convincing explanation for the empirical observations related to some dummy variables of the model, in particular that of monetary union.

The microeconomic context related to the theory of entry and exit of the market shows the importance of expectations in the decision-making of the enterprise. In the presence of sunk costs, the enterprises try to predict their future profit flows in order to decide whether to participate or not in the market. In any case, it avoids future unfavorable engagements. Then, this context makes it possible to introduce the expectations into the trade model.

By introducing the lagged variable of trade into the gravity model, the international economists have tried to capture the effects of sunk costs on bilateral trade. In this paper, we have indicated the theoretical difficulties of such modeling. Indeed, the lagged variable of trade represents only previous expectations on the bilateral trade. In addition, the absence of the relationship between current trade and the lagged variable, following the second period $(t-2)$ and the continuity of the sunk costs in time, shows that the hysteresis is not a perfect interpretation for the sunk costs presented in bilateral trade.

By developing the model of Anderson and Wincoop (2003), we have introduced, for the first time, the expectations term into the gravity model. The gravity model deduced from such a development takes into account the *expected relative trade costs* to determine the bilateral trade model. Moreover, we have suggested the estimation method of the expected growth rate of the bilateral trade costs β^e_{t+k}. This makes it possible to model the effects of the expected trade costs on the current trade volume by the gravity model.

Lastly, it is obviously seen that the expectations term could present the best explanations for the effects of some explanatory variables usually used in the gravity models.

A Determination of β:

In the formula (13), the element that represents the expectations term is the net growth rate of expected trade costs between i and j at the period $t+k$: β^e_{t+k}. In this appendix we explain how this term is defined. In fact, three elements participate in the determination of β^e_{t+k}: 1- empirical observations about the past behavior of β; 2- the sum of current information concerning the trade costs between partners; 3- an economic model which predicts the future trajectory of β. These three elements constitute the calculation technology of β^e_{t+k}.

Let us introduce here the formula (14) of the paper:

$$t^{eT}_{ijt} = \frac{\sum\limits_{k=0}^{T} \left(1 + \beta^e_{t+k} \mid \Omega_t\right) t_{ijt}\delta^k}{T} \tag{1}$$

If we suppose that $t^c_{ij,t-1}$ and β^c_{t-1} are the only element of the sum of economic agent information at the period t , t^e_{ijt} is defined in the following way[14]:

$$t^e_{ijt} = (1 + \beta^c_{t-1})t^c_{ij,t-1} = t_{ijt} \tag{2}$$

Where $t^c_{ij,t-1}$ and β^c_{t-1} respectively represent the last calculations of the economic agent on the parameters t_{ij} and β at the period $t-1$.

In this case:

$$\beta^e_t = \varphi\left(\Omega_t\right) = \varphi\left(\beta^c_{t-1}, t^c_{ij,t-1}\right) = \beta_t \tag{3}$$

Then, the formula (3) gives us the determination rule of the value of β through time.

[14] Dixon and Rankin (1995) determine the expected inflation rate for the next period by the multiplication of the present inflation rate and the growth of this rate through time.

This trajectory will determine the agent expectations about the value of β at the following time if nothing else is added to the sum of Ω_t. In other words, in this case the agent expects the same trajectory for β in the future as that carried out in the past.

On the other hand, additional information can change the following trajectory of β from its past trajectory. The formula below shows various possibilities for the trajectory of β according to values obtained by α:

$$\varphi\left(\beta_{t-1}^{c}\right) = \alpha\beta_{t-1}^{c} \tag{4}$$

where $\alpha \geqslant 0$. Since the past values $\beta_{t-1}$and $t_{ij,t-1}$ are visible, we have: $t_{ijt} = (1+\beta_{t-1})t_{ij,t-1}$. However, the growth rate of the trade costs for the period t (β_t) will be different from its previous value, if $\alpha \neq 1$:

$$\beta_t = \alpha\beta_{t-1} \tag{5}$$

If $\alpha = 0$, β_t will be equal to zero. This means that the bilateral trade costs are fixed through the time: $t_{ijt} = t_{ij,t-1}$. In addition, $\alpha = 1$ means that the next growth rate of the bilateral trade costs remains as before. Indeed, in this case, the trajectory of β projects into the future. On the other hand, if α is defined in order to respect $\alpha \boldsymbol{\epsilon} \left(0,1\right)$, the trade cost will increase for the following period but with a smaller rate than before. In the same way, the trade cost will increase in the future in a stronger way than before if $\alpha \geqslant 1$.

In fact, the economic agents' expectations formed by existing information take part to determine the value of α and consequently the value of β for the following periods.

B Matrix forms:

$$
\begin{bmatrix} \beta_{ij,t}^{1} \\ \beta_{ij,t}^{2} \\ \vdots \\ \beta_{ij,t}^{K} \end{bmatrix} = \begin{bmatrix} \alpha_{0}^{1} \\ \alpha_{0}^{2} \\ \vdots \\ \alpha_{0}^{K} \end{bmatrix} + \begin{bmatrix} \begin{bmatrix} \alpha^{11} & \alpha^{12} & .. & \alpha^{1M} \end{bmatrix} \begin{bmatrix} \sigma_{ij,t}^{11} \\ \sigma_{ij,t}^{12} \\ \vdots \\ \sigma_{ij,t}^{1M} \end{bmatrix} \\ \begin{bmatrix} \alpha^{21} & \alpha^{22} & .. & \alpha^{2M} \end{bmatrix} \begin{bmatrix} \sigma_{ij,t}^{21} \\ \sigma_{ij,t}^{22} \\ \vdots \\ \sigma_{ij,t}^{2M} \end{bmatrix} \\ \vdots \\ \begin{bmatrix} \alpha^{K1} & \alpha^{K2} & .. & \alpha^{KM} \end{bmatrix} \begin{bmatrix} \sigma_{ij,t}^{K1} \\ \sigma_{ij,t}^{K2} \\ \vdots \\ \sigma_{ij,t}^{KM} \end{bmatrix} \end{bmatrix} + \begin{bmatrix} \begin{bmatrix} \gamma^{11} & \gamma^{12} & .. & \gamma^{1N} \end{bmatrix} \begin{bmatrix} \delta_{i,t}^{11} \\ \delta_{i,t}^{12} \\ \vdots \\ \delta_{i,t}^{1N} \end{bmatrix} \\ \begin{bmatrix} \gamma^{21} & \gamma^{22} & .. & \gamma^{2N} \end{bmatrix} \begin{bmatrix} \delta_{i,t}^{21} \\ \delta_{i,t}^{22} \\ \vdots \\ \delta_{i,t}^{2N} \end{bmatrix} \\ \vdots \\ \begin{bmatrix} \gamma^{K1} & \gamma^{K2} & .. & \gamma^{KN} \end{bmatrix} \begin{bmatrix} \delta_{i,t}^{K1} \\ \delta_{i,t}^{K2} \\ \vdots \\ \delta_{i,t}^{KN} \end{bmatrix} \end{bmatrix} +
$$

$$
\begin{bmatrix} \begin{bmatrix} \lambda^{11} & \lambda^{12} & .. & \lambda^{1P} \end{bmatrix} \begin{bmatrix} \nu_{j,t}^{11} \\ \nu_{j,t}^{12} \\ \vdots \\ \nu_{j,t}^{1P} \end{bmatrix} \\ \begin{bmatrix} \lambda^{21} & \lambda^{22} & .. & \lambda^{2P} \end{bmatrix} \begin{bmatrix} \nu_{j,t}^{21} \\ \nu_{j,t}^{22} \\ \vdots \\ \nu_{j,t}^{2P} \end{bmatrix} \\ \vdots \\ \begin{bmatrix} \lambda^{K1} & \lambda^{K2} & .. & \lambda^{KP} \end{bmatrix} \begin{bmatrix} \nu_{j,t}^{K1} \\ \nu_{j,t}^{K2} \\ \vdots \\ \nu_{j,t}^{KP} \end{bmatrix} \end{bmatrix} + \begin{bmatrix} \varepsilon_{ij,t}^{1} \\ \varepsilon_{ij,t}^{2} \\ \vdots \\ \varepsilon_{ij,t}^{K} \end{bmatrix}
$$

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