Application of the Game theory to Trade between WAEMU and the EU

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ABSTRACT------*The aim of this paper is to analyze the issues of the implementation of the EPAs (Economic Partnership Agreements) by the WAEMU (West African Economic and Monetary Union) countries in the context of trade relations between this Union and the EU (European Union). The tool of game theory is used through the coalition theory to formalize exchange gains between the different entities. The results show that it is advantageous for WAEMU countries to sign EPAs since a partnership between countries of different development levels provides more trade gains than a partnership with a bloc of similar countries.*

Keywords--- Trade, Economic Partnership Agreements, economic integration, game theory

1. INTRODUCTION

Over the last few years, trade between emerging countries and West Africa has increased significantly. The results of an analysis on the geographic orientation of foreign trade by the BCEAO (the Central Bank of West African States) in 2006[1], revealed that Europe remains the first business partner of the WAEMU with, however, a constant decline in the exchange rates over the years for the benefit of African, American and Asian continents.

The share of exports to the European Union (EU) was of 33.7% in 2005 against 50.3% in 1995, with that of France dropping from 17.4% to 14.5%. This share emerged to 34.1% for Africa in 2005 due to the dynamism of sales related to Oil products and gold to the countries of the continent, including Nigeria, Ghana and South Africa. The United States, main destination in the Americas, accounted for 9.3% of total exports in 2005 against 3.1% in 1995 certainly because of the increase in sales of crude oil from Cote d'Ivoire. Exports to Asia have also increased, due mainly to the increasing orientation of the cotton sales to China, which is the leading destination for this product. The weight of this country in the total exports of the WAEMU rose from 0.5% in 2000 to 3.7% in 2005.

Concerning the imports, the EU, while remaining the first business partner saw its share in the purchases of the WAEMU Member States decrease from 58.2% in 1995 to 38.7% in 2005 to the advantage of Africa and Asia. Particularly, the market share of the traditional partner, namely France, declined from 21.5% in 2005 to 33.0% in 1995. The weight of African countries shifted from 30.6% in 2005 to less than 20.0% in 1995, under the leadership of Nigeria, one of the leading suppliers of the area in crude oil. In Asia, China and the India continued their progress on the sub regional market because of the competitiveness of the goods sold, representing respectively a share of 4.1% and 2.0% against 3.3% and 1.0% in 2000. The share of foreign purchases from China in the total imports of the WAEMU countries was of 11.2% in 2011. China is the second largest supplier of the countries of the Union behind France[2].

Despite the diversification over time of the geographical direction of trade, the EU remains the main business partner of the WAEMU. However, it should be noted that the principles and privileges that governed their business relationships follow a new approach in order to be in line with the standards of the world trade (Faucheux and al., 2005).

Partnership relations between the ACP countries - and therefore WAEMU - and those of the EU were made by historical ties based on the principle of solidarity and development, with the establishment and renewal of several conventions and cooperation agreements. This North-South cooperation developed with the ACP-EU convention with weak effects generated. And its substitution for the EPAs, to comply with the various clauses of WTO, raises concerns about losses the public funds would experience and the destruction of the nascent industry because of the strong competition of EU countries. The main motivation of the EPAs[3] is therefore to ensure the compatibility of ACP - EU trade relations with WTO standards and get rid of the contradictions born with the clause of the Most Favored Nation

[1] Banque de France, Rapport Annuel Zone Franc, (2006).
[2] BCEAO (2012).
[3] Cf. Dufau et Souare (2011).

which states that the trade concessions granted by a Member State of the WTO should be automatically extended to all. There may be an exception only if the preferential treatment at stake is related to development concerns or when related to free trade areas. The EPA consists in establishing a reciprocal free trade area between the EU and the ACP regions and supporting existing regional integration initiatives of ACP countries, and not to impede them (Cf. Faucheux and al., 2005; CRES, 2011). However, the observation made at the level of West Africa, shows that countries have divergent interests concerning the signature of EPAs; some States have signed an interim EPA while Less Developed Countries (LDCs) don't express any interest because they don't see the advantage the EPA entails for them and are less exposed to risks in the absence of a general agreement[4].

Thus, this article, based on the work of Stoffaes (1978), intends to analyze the issues of the implementation of the EPAs within the framework of the trade relations between the WAEMU and the EU. The EPA issues lie firstly at the level of the West African countries; the EPA may impede the regional integration process of these different countries. In addition, at the level of the EU, if the concerns of its partners are not taken into account, they will further dissociate from its positions in multilateral trade negotiations, while China occupies a more important place in the African landscape. This analysis shows the benefits arising from the implementation of EPAs for WAEMU's countries.

The article is organized as follows: section 2 deals with the review of the literature related to the use of the game theory in the analysis of international trade. Sections 3 and 4 describe respectively the methodology adopted and the results of analysis. Section 5 concludes the work, while the last section presents the references.

2. REVIEW OF LITERATURE

The game theory, defined as *' the mathematical formalization of cooperative or conflictual situations among several rational agents (players) »,* is an analysis tool of human behaviour used to describe and analyze many economic and social relationships in the form of strategic games. This method of analysis has been used by many authors including Laskar (1996) who analyzed the regional agreements with a cooperative games approach. He explained, through a model common to three countries, the formal conditions that can help reach regional agreements and gave some examples from the literature. As for Stoffaes (1981), he applied the game theory to international economic relationships, specifically to trade and economic interdependence among nations with different levels of development, to optimal customs zones and international oil market. He developed models to formalize each case. It is the results of these analyses that will be used to describe the trade between WAEMU and the EU in this study.

Many works have already been carried out on the impact of EPAs on ACP countries including Faivre and al. (2004), PWC and al. (2005), McKay and al. (2005), Milner and al. (2008, 2009) to name but a few. In most studies, quantitative analyses of the impact of the EPAs on trade flows were performed in a partial or general equilibrium framework. This is the case of Busse and al. (2004) who used a partial equilibrium model. Similarly, the report (2005) of PCI International Consulting entitled " *Etude d'impact de l'Accord de Partenariat Economique Union Européenne-Afrique de l'Ouest sur l'économie du Burkina Faso*" (Impact analysis of the economic partnership agreement EU - West Africa concerning the economy of Burkina Faso) referred to a partial equilibrium model to trace the supply and demand of goods on the Burkina Faso market. However, to our knowledge, no study on trade relations between WAEMU and EU, nor on the impact of the EPA, has used the game theory as an analytical tool.

The distinctive feature of this study is to specify the trade relations between WAEMU and EU using the game theory on the basis of the results of the work of Stoffaes (1981). We will apply in this paper the general framework established by Stoffaes (1981) to the specific case of the EU and WAEMU. We use the methodology developed in his paper.

3. METHODOLOGY AND ANALYTICAL FRAMEWORK

3.1. Methodology

According to Stoffaes (1981), the International economic relationships are a good potential field for the application of the game theory since globalization of markets increases the interdependence of national economies in considerable proportions. Thus, trade partners have interest in agreeing on solutions that preserve their respective interests lest the trade condition should drive each one of them to a mutually harmful protectionism.

A game is a strategic interaction between two or many players in which every player can choose between several possible strategies. Each strategy translates into a gain, usually represented by a number. This gain depends on the strategies of all the players in the game. The game theory is based on the assumption that players are rational actors, that is, they seek to maximize their own gains.

Thus, a game between two people includes two partners, each having the choice between several strategies. The choice of a couple of strategies by the two players results in a gain for each of them. When the number of countries is more than two in the set of the game, it is necessary to resort to the theory of coalitions. This method will be used to

[4] In July 2014, Heads of States in West Africa have permanently approved this agreement. It is viewed by EU as a landmark stride for signing and implementing the EPAs.

analyze the gains from the implementation of a free trade area between the Europe Union (EU) and Africa in the context of the EPAs. The study establishes scenarios from which different coalitions between developed and developing countries are formed.

The value of a coalition of n-actors is defined as the sum of the earnings of the players in the coalition when it plays its minimax strategy, i.e. one that ensures the maximum profit in the most unfavorable conditions. In a coalition, partners agree to submit their individual decisions to a common authority. The latter will play the optimal strategy for the community represented by the coalition. Then the coalition partners will agree to share the common benefit between them. The grand coalition, which brings together all the partners of the game is viable if each one can expect to get in the distribution of the common benefit, a profit higher than what he can get by playing his own separately, or by being part of a coalition with a more limited number of partners. The core of the game is represented by all the distributions of the collective gain of the grand coalition to each partner to what everyone can get in small-size coalitions.

Determining the core allows to know whether an agreement between the parties (EU and developing countries) is possible or beneficial for all. If the core is empty, the grand coalition is not sustainable and there are conflicts between opposing blocs. Shapley's solution is the one that assigns to each, the common benefit on the basis of a fair rule i.e. that ensures each identical additional gain compared to what he gets playing his best individual strategy.

3.2. Analytical framework

Let's consider the following coalition game or the strategic game (N, v) defined by:

- $N = (1, \dots, n)$ a set of players
- v, the value or utility of the coalition, is a characteristic function that associates a value $v(C) \in R$ with each coalition C of N. To each coalition, a value $v(C)$ can be assigned representing the maximum attainable value by the coalition C after its optimization problem is solved ; For each coalition C, the value $v(C)$ is the total payment that can be shared among the players belonging to the coalition of C ;
- $v(N)$ is the value of the grand coalition which includes all the players.
- A set of strategies $S_i = (s_1, \dots, s_{ni})$ for each player i
- C a coalition of a group of players, subset of N, cooperating together
- A payment function $x_i: s_1 \dots s_n \rightarrow R$ for each player i, combining the gains of player i for each set of strategies.

Our assumptions are as follow:

- We consider that the agents are rational, that is, they try to arrive at a situation that is the best for them
- Utility is the measure of each situation regarding the agent; it is neither a situation of material gain, nor a measure of monetary gain but a subjective measure of the agent's satisfaction;
- Transferable Utility (« TU games »): we can add up the utilities of the players of a coalition and redistribute them among its members.
- Superadditivity means that the value of a coalition is always higher than the sum of the values of the subsets that compose the coalition.

$$v(S_1 \cup S_2) \geq v(S_1) + v(S_2) \forall\, S_1, S_2 \subset N \;\; with \;\; S_1 \cap S_2 = \emptyset$$

Let's assume first that the international economic exchange game features two players; one industrialized (I): the European Union and other developing (D): WAEMU. To show it schematically, let's also assume that each of these two groups of countries has the choice between two contrasting attitudes in front of the constraints posed by their opening of their market to the world. The one, the autonomy strategy (A), seeks to curb economic integration mechanisms that develop between the two nations; the other one, the specialization[5] strategy (S) seeks instead to support the integration and the division of labour between the two groups of nations.

These strategies have different content depending on whether the developed countries (the countries of the EU) (I) or the developing countries (WAEMU countries) (D). But their common characteristic is clear: S is an open-market policy, A is a protectionism policy. Since each of the two players (I and D) has a choice between two strategies (A and S).

The analytical framework will extend to West Africa overall since EPAs are concerned with large regional blocs (WAEMU part of ECOWAS, the large block of West Africa). In this model, West Africa has been divided into "less developed countries (LDCs)" and non-LDCs; these countries have different characteristics and interests that might influence their decision to sign the EPAs. The model includes three countries with different features: a developed country, a less developed country and a non-less developed country. Thus, there are three players: developed country (EU), LDC (Guinea) and non-LDC (Cote d'Ivoire). This distinction is made because the countries don't share the same interests in signing the EPAs as they are LDCs and non-LDCs.

[5] The concepts of specialization and autonomy have a broader meaning than the classic concepts of openness to free trade and protectionism. They involve the use of methods of structural economic policy that are much more complex and varied than the simple use of customs procedures.

We will also assume that within a given coalition, the members still have interest in playing free trade with each other and mutual specialization, which ensures the maximum gain for the coalition, and to redistribute this gain equally between partners. Also an opened nation has much to lose in playing the strategy of autonomy than an inward-looking nation. Similarly, the specialization between an opened nation and an inward-looking nation is highly profitable for the coalition and involves virtually no redistribution of common gains among the partners. Still, specialization between an opened and an inward-looking nation remains profitable, but is unstable and involves a compensatory redistribution to the inward-looking nation. Finally, the division of labour between two inward-looking nations is only poorly profitable for the partners.

Given the EU, representing an opened industrialized country (I_{op}); Cote d'Ivoire, an opened developing country (D_{op}) and Guinea, a highly inward-looking developing country (D_{in}). The quantitative assessments below are purely arbitrary; nevertheless, they relatively try to reflect the conclusions of the analysis of the different scenarios. Thus, I generally benefits more than D, economically and politically, from the development of trade according to the theory of unequal Exchange; this is why the gain of I is + 4 while D gets only + 2 in the free trade scenario, etc. The different gains are presented in the following table:

Table 1: Gains of the UE and WAEMU according to the different strategies

Option	I(S) and D(S) : Free trade		I(S) and D(A) : Generalized preferences		I(A) and D(S) : neo colonialism		I(A) and D(A) : isolation	
Effect on / Criteria	I	D	I	D	I	D	I	D
Economic	+4	+2	-1	+2	+1	-1	-1	0
Political	0	-1	-1	+1	+2	-2	+1	0
Social	-2	+1	-2	0	+2	-1	+1	-2

Source : Stoffaes (1981)

The analysis will consider four cases that characterize the EU on the one hand, and the WAEMU on the other hand, according to criteria based on economic, political and social objectives translated by a weighting system in the table below, with arbitrary figures seeking to reflect relative arbitrations:

Table 2: Weighting of the criteria according to the four types of choice

Criteria / Country	Economic	Political	Social	Total weights
EU Opened (I_{op})	4	1	1	6
EU Inward-looking (I_{in})	1	2	3	6
WAEMU Opened (D_{op})	6	0	0	6
WAEMU Inward-looking (D_{in})	2	3	1	6

Source : Stoffaes (1981) and author

The gain of I_{op} in the situation of inward-looking is achieved by carrying out the weighted sum gains by I_{op} in the economic, political and social fields: $v = 4 \times (-1) + 1 \times 1 + 1 \times 1 = -2$

- When I_{op} plays strategy A against partner which choose A, its gain is $v = 4 \times (-1) + 1 \times 1 + 1 \times 1 = -2$.
- When I_{in} plays strategy A against partner which choose A, its gains is $v = 1 \times (-1) + 2 \times 1 + 3 \times 1 = 4$.
- For D_{op} playing A against partner playing A, its gain is $v = 6 \times 0 + 0 \times 0 + 0 \times (-2) = 0$.
- D_{in} plays A against partner playing A and gets: $v = 2 \times 0 + 3 \times 0 + 1 \times (-2) = -2$.
- I_{op} plays S against his partner D playing S: its gain is $v = 4 \times 4 + 1 \times 0 + 1 \times (-2) = 14$.
- I_{in} plays S against his partner D playing S: $v = 1 \times 4 + 2 \times 0 + 3 \times (-2) = -2$.
- For D_{op} playing S against his partner D playing S, its gain is $v = 6 \times 2 + 0 \times -1 + 0 \times 1 = 12$.
- D_{in} plays S against his partner D playing S and gets: $v = 2 \times 2 + 3 \times (-1) + 1 \times 1 = 2$.

In the event that the coalition consists of two countries with complementary levels of development (I: developed and D: developing), by assumption, its value will be the sum of the gains achieved by both partners in case of cooperation (example: I_{op} and D_{op} playing S between them against the rest of the world: v = 14 + 12 = 26). When the coalition will include two countries with the same level of development I_{op} and I_{in} or D_{op} and D_{in}), the hypothesis of simple addition of

the earnings of both partners will prevail, as if they were individually playing A against the rest of the world playing A: v = 0 + (-2) = -2

Coalition with one player

The minimax strategy is the autonomy regarding the rest of the world:

- v (I_{op}) = -2
- v (D_{op}) = 0
- v (D_{in}) = -2

Coalition with two players

The minimax strategy is the concerted autonomy of the coalition partners (free trade between them) regarding the rest of the world:

- v (I_{op}, D_{op}) = 14+12 = 26.

This is the case for example of blocks consisting of mother countries and their colonial empires (France, Member of the EU and Cote d'Ivoire, Member of the WAEMU) which are an illustration of this type of coalition.

- v (I_{op}, D_{in}) = 14+2 = 16.

It is the alliance of an opened country of the North (Germany, member of the EU) and an inward-looking country of the South (Guinea, a West African country) against the rest of the world.

- v (D_{op}, D_{in}) = 0+ (-2) = -2.

This is the scenario of economic integration among developing countries of the South forming the isolated block of the North. This is the example of cooperation between Côte d'Ivoire and Guinea.

Coalition with three players

- v (I_{op}, D_{op}, D_{in}) = 14+12+2= 28.

This scenario corresponds to the cooperation between the countries of the EU, France for example, and the ECOWAS (Economic Community of West African States) countries: Côte d'Ivoire and Guinea.

4. RESULTS OF THE GAME AND ANALYSIS OF THE GAINS

The objective of the study, as already mentioned, is to know whether an agreement between the EU and West African countries is possible and beneficial for all parties. To form the coalitions, three categories of countries were selected to represent the EU and West African Countries: developed countries, non-less developed countries and less developed countries.

The core principle is that no coalition has a value higher than that of the core. All the distributions in the core meets two conditions:

- ✓ $\sum_{i\in N} x_i = v(N)$
- ✓ $\sum_{i\in S} x_i \geq v(S), \forall S \in N$

For a superadditive game, a non-empty core involves a large stable coalition. What is at stake is to determine the core of the game and know whether it is empty or not.

The core of the game is the redistribution of the gain of the grand free-trade coalition that helps to give to each country more than it would have in integrating a given smaller block. It's all, if any, the charges not controlled by possible coalitions, i.e. the set of triples (x, y, z), representing respectively the provisions of I_{op}, D_{op}, D_{in} satisfying the system of seven constraints below which expresses the set of the relations: $x \geq v(I_{op}), x + y \geq v(I_{op}, D_{op})$ etc.

The constraints for x, y and z to be solution of the core are:

$$\begin{cases} x \geq -2, \ \ y \geq 0, \ \ z \geq -2 \\ x + y \geq 26, \ \ x + z \geq 16, \ \ y + z \geq -2 \\ x + y + z = 28 \end{cases}$$

These constraints give the following system:

$$\begin{cases} x \geq -2 & (1) \\ y \geq 0, & (2) \\ z \geq -2 & (3) \\ x + y \geq 26 & (4) \\ x + z \geq 16 & (5) \\ y + z \geq -2 & (6) \\ x + y + z = 28 & (7) \end{cases}$$

(7) and (4)$\Longrightarrow\ 28 - z \geq 26 \Longrightarrow\ z \leq -2$; when we add it to (3) $\boldsymbol{z \geq -2}$**,** we get : $\boldsymbol{-2 \leq z \leq 2}$

We follow the same pattern to determine x and y.

After resolution of the system we have:

$$\begin{cases} x + y + z = 28 \\ -2 \leq x \leq 30 \\ 0 \leq y \leq 12 \\ -2 \leq z \leq 2 \end{cases}$$

With the assumptions used the core of the game, for which the general free trade scenario is feasible, exists and is not empty.

$(x, y, z) / -2 \leq x \leq 30;\ 0 \leq y \leq 12\ ; -2 \leq z \leq 2$

This implies the following distribution in the core which is not the only solution (any distribution that verifies the conditions set out above is a solution and included in the core of the game)

$$C(N, v) = (\{14, 12, 2\})$$

The gain of the EU (developed country) is represented by x; the payment of Cote d'Ivoire (non-less developed country) is y and Guinea (less developed country) is z. This distribution is efficient in the sense that the EU is a privileged player which represents the industrialized countries while Côte d'Ivoire and Guinea are developing countries.

An imputation of the core can therefore be defined as a system of redistribution of common gain of the grand coalition to each of the partners allowing them respectively to get more than in any partial coalition they could have join. It is only in this condition that the grand coalition is viable, i.e. when one or all the nations cooperate within a multilateral free trade at the global level, because it is on this condition only that the common gain is sufficient to persuade a partner to renounce to join a small-size coalition. The European Union, Cote d'Ivoire and Guinea coalition is then viable given that the common gain is sufficient to enable each partner to get more than in any other partial coalition, as a coalition of countries with different levels of development is more profitable in the Exchange than a block of countries with similar features. Signing the establishment of a free trade area between the EU and the West African countries can be beneficial for all even if the EU is the one that gets the highest profit given the structure and the size of its economy. A coalition between West African countries will not allow them to have more profit given the size of their domestic market, the nature of the products traded.

5. CONCLUSION

This paper, through the game theory, helped in describing, on the one hand, some aspects of international economic relations between the EU and the WAEMU countries by using the concepts of the game theory, and on the other hand, analyzing the implementation of a free trade area between the EU and the ACP countries, specifically West African countries through the signature of the Economic Partnership Agreements.

It appears that the WAEMU countries would benefit from implementing EPAs by liberalizing their trade and by expanding their productive base and export as a partnership with countries with levels of development different from them is more profitable in the Exchange compared to a block of similar countries. These conclusions are valid with the assumptions set out in this paper and the recent evolution of the news on EPAs corroborates the results.

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