Game theoretic approach to bulgaria's eu accession

Assoc. Prof. Dr. Tuncay Can,
Marmara University
Assoc. Prof. Dr. A. Mete Çilingirtürk,
Marmara University

European Union is a global trade actor with a high volume of exports more than the sum of US, Japan and Canada as twice of its imports as a single market. This is perhaps due to its oldest most successfully integrated common trade policy [Meunier, 2005: p.4]. That makes the EU one of the most powerful trade negotiator, as letting the individual member nations nonrigid, autonomous trader. The Council of Ministers represents the protectionist national interests for a special region or industry [Meunier, 2005: p.9]. As EU involvement is limited in some policy domains, the independent nations are intending to increase national welfare by contributing the Union's economic activity. According to the economic aspects, agriculture is one of the most important EU involvement areas beside the sectoral policies on the transportation and communication networks [Alesina, et.al., 2005: pp.276-278]. At the same time EU benefits from economies of scale, but confronts an increasing cost of enlargement.

The actors EU and the candidate nation deal with a critical decision whether to accept the nation as the member and to harmonize the homogeneity through policies or offering another base for economic coordination or integration. On the other hand the candidate nation should also decide optimum offer for national welfare maximization. The alternatives for the EU might be limited with four commonly applied processes on economic agreements. These are the adoption of the Common External Tariff, implication of a regional trade agreement between Bulgaria and EU, full EU accession and return to the MFN tariff schedule. Since 1957 the EU has been a customs union with a Common External Tariff (CET) completed at the Uruguay Raund in 1993, which harmonized tariffs applied by EU countries to non-members while eliminating internal tariffs [Ehrlich, 2005]. . However, national production capacity and structure caused variations in tariff bounds on different products. According to the rules of origin on trade among the EU's free trade agreement (FTA) partners reduced trade among the EU's trade partners without changing the degree of tariff preference [Augier, et.al., 2005: pp. 567-624].

Methodology

The study of conflict in mathematical form game theory- has its roots in the 1920's and 1930's with early work by Von Neumann and Borel. It was not until 1944 that great interest was attracted to the subject when Von Neumann and Morgenstern published *The Theory of Games and Economic Behaviour*. Game theory was then caught up in the general rapid growth of operational research after the Second World War. A game is collection of rules, known to all participants, determining what players may do and the pay-offs that result from their choices of courses of action, which are the tactical alternatives. A strategy is set of decisions formulated in advance of play specifying the choice, or the means of choice of courses of action in every contingency [Wilkes, 1989: p.420]. In the game theory, the value of the objective function of one decision maker will depend not only upon his own actions but also upon the actions of others. It is the study of such situations and in general both conflict and cooperation are involved [Wilkes, 1989: p.420].

Two player zero-sum games can be expressed as Linear Programming since LP problems involve just one decision maker. But it should be recalled that with each maximizing LP problem (the primal) there is associated a minimizing problem the dual, which has the same

optimal value of the objective function. The maximizing player's problem and the minimizing player's problem to the dual [Wilkes, 1989: p.433]. In many two person zero-sum games it will not be possible for the players to employ pure strategies, because the payoff matrix does not have a saddle point. Where there is not a saddle point, the players must play each strategy a certain percentage of the time. This situation is referred to as a mixed-strategy game [Markland, et.al., 1987: p.690].

Player A's optimal probabilities x_i , i=1, 2, …,m , can be determined by solving the following maximin problem,

$$\max_{x_i}\left\{\min\left(\sum_{i=1}^{m} a_{i1}x_i, \sum_{i=1}^{m} a_{i2}x_i, \ldots, \sum_{i=1}^{m} a_{in}x_i\right)\right\}$$

$$\sum_{i=1}^{m} x_i = 1$$

$$x_i \geq 0, \qquad i = 1,2,\ldots,m \tag{1}$$

To transform the problem into linear programming, let

$$v = \min\left(\sum_{i=1}^{m} a_{i1}x_i, \sum_{i=1}^{m} a_{i2}x_i, \ldots, \sum_{i=1}^{m} a_{in}x_i\right) \tag{2}$$

The equation implies that

$$\sum_{i=1}^{m} a_{ij}x_i \geq v, \qquad j = 1,2,\ldots,n \tag{3}$$

The player A's problem thus can be written as [Taha, 1997: p.563]

Maximize $z = v$

subject to

$$\sum_{i=1}^{m} a_{ij}x_i \geq v \qquad , i = 1,2,\ldots,n$$

$$\sum_{i=1}^{m} x_i = 1$$

$$x_i \geq 0 \qquad , i = 1,2,\ldots,m$$

v unrestricted (4)

Note that the value of the game v is unrestricted in sign [Taha: p.564]. Player B's optimal strategies y1, y2, … and yn are determined by solving the problem

$$\min_{y_j}\left\{\max\left(\sum_{j=1}^{n} a_{1j}y_j, \sum_{j=1}^{n} a_{2j}y_j, \ldots, \sum_{j=1}^{n} a_{mj}y_j\right)\right\}$$

$$\sum_{j=1}^{n} y_j = 1$$

$$y_j \geq 0, \qquad j = 1,2,\ldots,n \tag{5}$$

Using a procedure similar to that followed with A's problem, B's problem reduces to

Minimize $w = v$

subject to

$$\sum_{j=1}^{n} a_{ij}y_j \leq v \qquad , i = 1,2,\ldots,n$$

$$\sum_{j=1}^{n} y_j = 1$$

$$y_j \geq 0 \qquad , j = 1,2,\ldots,n$$

v unrestricted (6)

The two problems optimize the same unrestricted variable v, the value of the game. The reason is that B's problem is the dual of A's problem. This means that the optimal solution of one problem automatically yields the optimal solution to the other [Taha: p.564].

EU Behavioral Scenarios and Bulgaria Sectoral Output

This paper depends on the results of the working paper on the economic implications of the EU accession of Bulgaria since our research is settle on measurable criteria of the accession process and economic aspects. That research depends on developing CGE World Trade Models simulating four scenarios that are adoption of the Common External Tariff, implication of a regional trade agreement between Bulgaria and EU, full EU accession and return to the MFN tariff schedule [Baourakis et.al., 2008]. These four scenarios are the states of the natures of the EU as an actor or player. However, Bulgaria at the other side focuses on national wealth maximization. The national

production was assumed Leontief technology with fixed production coefficients between primary and intermediate inputs, which would be directly affected through economic policies of integration. So the sectoral aggregated output results would present the industrial structure of the Bulgaria's new economy. The gains are quantitative effects in percentage changes. These are accepted as the pay-off matrix for the decision making problem on the percentage production of the sectoral planning, which maximizes the growth rate simultaneously with the decision on the policy related to the EU. The following table is 10x4 payoff matrix [aij].

Table 1 Sectoral Quantitative Effects of Scenarios

Bulgaria's Sectoral Preference	Sectoral Aggregation	Policy to European Union			
		B_1:CET	B_2:RTA	B_3:Full Member	B_4:MFN Tariff
	A_1:Creals	O,35	1,63	1,89	0,18
	A_2:Vegetables & Fruits	-0,62	0,87	0,28	0,62
	A_3:Meat &Fats	-2,38	1,91	-0,51	-1,21
	A_4:Dairy	-0,42	1,71	1,39	0,23
	A_5:Fishing	-0,06	1,52	1,49	0,20
	A_6:Food	-0,46	5,37	5,09	0,07
	A_7:Textile	-4,06	-5,04	-9,31	-7,23
	A_8:Wearing	7,93	-6,73	0,40	-21,64
	A_9:Motor Vehicles	-2,13	-1,52	-3,67	1,00
	A_{10}:Machinery	0,24	-3,27	-3,18	2,13

Source: Baourakis, G, C Lakatos, A Xepapadeus, "Economic implications of the EU accession of Bulgaria and Romania: a CGE approach", Working Paper 08/1, TradeAG, 2008.

The percentage growth values a_{ij} (i=1,2,…,9,10 and j=1,2,3,4) in the pay-off matrix represents a gain for A player if they are positive and opposite gain for the EU if negative. When the value is zero, there is neither gain nor loss for both players. It could explicitly seem from the table, that the percentage growth at meat &fats production is dominated by the food production and cereals production dominates the growth at the textile production, because all the percentages are lower than the dominating sector values for all the EU policies.

Let player A's optimal mixed strategy vector shown as

$$\Gamma_A = \begin{pmatrix} A_1 & A_2 & A_{10} \\ x_1 & x_2 & x_{10} \end{pmatrix} \qquad (7)$$

and player B's optimal mixed strategy vector is

$$\Gamma_B = \begin{pmatrix} B_1 & B_2 & B_{10} \\ y_1 & y_2 & y_{10} \end{pmatrix} \qquad (8)$$

Player A's linear programming problem can be written as

Maximize $z = v$

subject to

$$\sum_{i=1}^{10} a_{ij} x_i \geq v \qquad , i = 1,2,3,4$$

$$\sum_{i=1}^{10} x_i = 1$$

$$x_i \geq 0 \qquad , i = 1,2,\ldots,10 \qquad (9)$$

and the player B's linear programming can be written as

Minimize $w = v$

subject to

$$\sum_{j=1}^{4} a_{ij} y_j \leq v \qquad , i = 1,2,\ldots,10$$

$$\sum_{j=1}^{4} y_j = 1$$

$$y_j \geq 0 \qquad , j = 1,2,3,4$$

The conflicting and cooperating sectoral planning strategy and EU policy of the Bulgarian government yields the following optimal mixed strategy under the given assumptions, solved by QSB program.

$$\Gamma_A = \begin{pmatrix} cereals & veg. & meat & dairy & fish. & food & text. & wear. & motor & mach. \\ 0,76 & 0 & 0 & 0 & 0 & 0 & 0 & 0,01 & 0 & 0,23 \end{pmatrix}$$

$$\Gamma_B = \begin{pmatrix} CET & RTA & Member & MFN \\ 0,71 & 0,07 & 0 & 0,22 \end{pmatrix}$$

Accordingly the value of the game v=0,40 at the optimal mixed strategy solution. As Bulgaria chooses mostly (71%) the Common External Tariff adoption and returns to some (22%) MFN tariff schedule rules instead of being full member to EU, could maximize its growth to 0,40 through planning its production 76% of cereals and 23% of machinery. However, this production planning solution gives 0,709 growth for Bulgarian production but as much loss for the EU. As the full member of the EU, Bulgaria maximizes its growth by the food industry. However, textile industry could a resources misusage for its economy, but EU as a whole benefit from it.

Conclusion

The intention of this paper is to show the applicability of the game theory to the regional or international unification or trade agreements. In general a policy of application to an established union should be a pure strategy as whether being a member or not. However, if there are alternative states of being part of the international trade, then actors shall determine their strategy to maximize self gains. Although this paper exercises just the economic growth as the gain, the pay-off matrix values can also utilize the social gains.

The membership to EU for Bulgaria was an economic success at the game. That is, it is not the optimal solution that maximizes both players gains. Accepting Bulgaria to the Union might a costly decision for the EU, but EU benefits from the expected growth of the Bulgarian production after the membership. The results let to assume EU's enlargement policy as a gain-gain game.

Bibliography

Alesina, A., I. Angeloni and L. Schuknecht, "What does the European Union do?", Public Choice, 123, 2005.

Augier P., M. Gasiorek, C. Lai Tong, et al., "The impact of rules of origin on trade flows", Economic Policy, 43, July 2005.

Baourakis, G, C Lakatos, A Xepapadeus, "Economic implications of the EU accession of Bulgaria and Romania: a CGE approach", Working Paper 08/1, Trade AG, 2008.

Ehrlich, Sean. "How Common is the Common External Tariff? Domestic Influences on European Union Trade Policy" Paper presented at the annual meeting of the The Midwest Political Science Association, Palmer House Hilton, Chicago, Illinois, Apr 07, 2005.

Markland, R.E., J.R. Sweigart, "Quantitative Methods: Applications to Managerial Decision Making", John Wiley&Sons, 1987.

Meunier, S., "Tradeing Voices", Princeton University Press, 2005.

Taha, H.A., "Operations Research an Introduction", 6th Ed., Prentice-Hall International, 1997.

Wilkes, M., "Operational Research Analysis and Applications", McGraw-Hill, 1989.