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International Aviation Carbon Taxation: Game between EU and Non-EU Countries

Meng Li[1], Guang-kuo Gao[2], Yongchong Wang[3]

1.Business School, University of Shanghai for Science and Technology, Shanghai, 200093, China
2.Business School, University of Shanghai for Science and Technology, Shanghai,200093,China
3.Business School, University of Shanghai for Science and Technology, Shanghai,200093,China

ABSTRACT: By the end of 2011,the failure by Air Transport Association Of American(ATA) and three other American airlines to challenge the new law on EU's aviation carbon emission fees triggered a new series of game between EU and Non-EU countries. In this paper, both the game between EU and Non-EU countries and the game between Non-EU countries are analyzed, it comes to the conclusion that the aviation taxation is inevitable, but how to realize it shall be proceed under the way admitted by all the countries in the world. On one hand our country shall take an active part in negotiating with EU, promoting the establishment of fairness, justice and reasonable aviation emission trade system with the help of International Civil Aviation Organization (ICAO).On the other hand we should speed up the establishment of our own emission trade system and include the aviation industry into it. For our airline company, a reform for its development and the realization of its low carbon operation in technology and management must be attained in the near future.

Key words: Aviation Taxation, Complete Information, Dynamic Game, Clever Pig Game

1. Introduction

On November 19, 2008, the European Parliament passed a new law to integrate the international aviation industry into the EU carbon emissions trading system, effect from January 1, 2012. This decision triggered strongly opposition by United States as well as multinational aviation industries. In December 2009, Air Transport Association Of American (ATA) and three other American airlines formally announced to sue the EU. While in December 21, 2011, the European Court of Justice rejected the appeal, which launched a new round of game between EU and Non-EU.

Previously foreign researchers on this area are more focused on whether to integrate aviation in emissions trading system or not,and the impact of levying aviation carbon tax on greenhouse gas emissions governance, the impact on the future development of the aviation industry and the policy of non-EU countries and the recommendations about that. Sascha Albers (2009) pointed out, the airline CO2 gas emissions will lead to European airlines face cost pressures and price increasing, but will not cause a significant reduction in air passenger demand; the European airline industry does not face a serious re-configuration. Dietrich（2012）pointed out that

aviation taxation was opposed by the majority of countries, but based on the EU's tough stance, the air transport industry should actively respond to find ways to lower the cost of reducing aviation carbon emissions, to reduce their costs through voluntary emission reduction or development of CDM project. Venai（2012）analyzes the development of the U.S. airline industry, measuring the carbon emissions intensify of various airlines, pointed out that trade protection of their aircraft as well as financial incentives innovation policy can promote the upgrading of the aircraft and reduce the aviation industry's carbon emissions. Combining with FAA's new air traffic management policies, it will significantly inhibit the expected growth of the aviation industry's carbon emissions.

Domestic scholars mainly focused on the study of the EU's aviation emission trade system and Non-EU countries' strategies to fight against EU's aviation carbon taxation .Wen Jie Han, Liu Guirong (2011) think that the EU carbon tax levied aviation industry huge operating costs which would increase in the short-term, also it would cause the decline in the competitiveness of our country's international aviation industry. The impact received by the aviation industry will also be conducted to GDP, employment opportunities, and international trade area. Li Zhanwu(2011) thinks that the EU's aviation carbon taxation is inevitable, China should take the initiative to take other measures such as "against", "playing cards", "make pressure", "negotiations", "health" and "hedge" and so on to deal with it. Tan Huaping(2011) gives a full introduction about EU ETS, he analyzed the legality of the EU ETS according to the existing framework of international law, and concluded that the international carbon taxation will cause unnecessary trade friction between EU and Non-EU countries, and even disputes which will also bring dealt a blow to the recovering of economics as well as international civil aviation industry.

Now it seems that, a research based on game theory between EU and Non-EU countries for international aviation carbon taxation has not studied before. This article will use the methods and theories of game theory to analyze the game between the EU and Non-EU countries, the game model will be established and correlation analysis will be taken, to predict future trends of the game. Recommendations are made for the government and the aviation industry to take action.

2. Game Model Establishment and Analysis

EU has decided to integrate aviation in the carbon emissions trading system formally early since 2008. EU and Non-EU Countries are the main participator of the Game on aviation carbon tax problems, although there are also games among Non-EU countries. Since that the game between EU and Non-EU countries has always been the main line which dominated the game throughout the process. We will establish and analyze the game model between EU and Non-EU countries in this thesis. Because the game between the two countries, however, is not only have something to do with the economic aspects, but also have inextricably linked with the political aspects. In order to use the methods of game theory smoothly, we will not consider about the political interest of game. We will establish the static game model and dynamic game model separately and analyze both of them in the following thesis. All these models are based on that both of them have the complete information for each other.

2.1 Complete Information Static Game

2.1.1Game Model Establishment

Assuming EU and Non-EU country are two rational individuals. EU has two strategies on international carbon taxation, levy and not levy, While there are also two strategies for the Non-EU countries, support levy (pay) and oppose it (reject to pay). EU have to pay a certain cost for levying aviation carbon tax to non-EU countries, but the aviation taxation will also bring EU some potential economic benefits except the aviation carbon tax revenue. For Non-EU country, it will cost a certain aviation carbon tax money to support the aviation taxation, but beccause the support of the governance of the greenhouse gas emission, Non-EU countries can also get part of the potential economic benefits in the future. But it's objections to the EU aviation carbon tax will also take it a certain cost.

Assume that the cost of EU for levying aviation carbon tax to non-EU country is α, The potential economic benefits of levying aviation carbon tax is β,

Non-EU country's support for aviation carbon taxation require to pay γ, the potential economic benefits for supporting is ε. Non-EU country's opposition to the aviation carbon tax will cost itself μ.

For Non-EU country, when EU imposed to levy aviation carbon tax, if it chose to support, its utility will be$(\varepsilon - \gamma)$; contrary, if it chose to oppose, its utility will be $(-\mu)$. While when EU decides not to levy aviation carbon tax, if the Non-EU country still support to levy aviation carbon tax, its utility will be ε;if Non-EU country oppose to levy aviation carbon tax ,then its utility will be 0. Similarly, for the EU country , when Non-EU country chose to support levying aviation's carbon tax, if EU levy aviation carbon tax, its utility will be $(\gamma + \beta - \alpha)$; while if EU chose not to levy aviation carbon tax, it's utility will be 0. When Non-EU countries oppose to levy aviation carbon tax, EU insist to levy, its utility will be $(\beta - \alpha)$; while if EU chose to give up levying aviation carbon tax, its utility will be 0.

The game strategy and utility of the EU and Non-EU countries are expressed in the following table(See Table 1).

Table 1 Complete information static game strategy type representation between the EU and non-EU countries

EU country / Non-EU country	Levying	Not levying
Support	$(\varepsilon - \gamma, \gamma + \beta - \alpha)$	(ε,0)
Opposite	$(-\mu, \beta - \alpha)$	(0,0)

2.1.2 Game Model Analysis

To consider the relationship between various parameters, we can draw the following points:

i)If EU can success levying aviation carbon tax, although EU has to pay the cost for making aviation carbon emissions trading rules, its potential economic benefits will far outweigh the potential economic benefits of the Non-EU countries to support the aviation carbon tax that $\beta > \varepsilon$.

ii) Due to the concern of the international countries for the issues of greenhouse gas emissions governance, all countries around the world have started the energy conservation work in the aviation industry. For EU, even it is confronted with opposition from Non-EU countries, its cost for levying aviation carbon tax to Non-EU countries must be minimal compared with the potential benefits to obtain, that is $\beta > \alpha$.

iii) For Non-EU countries, its opposition to EU's aviation carbon taxation must cost less than the aviation carbon tax it need to pay, that is $\mu < \gamma$. Otherwise Non-EU countries can do obediently pay aviation carbon tax while enjoying the potential economic benefits as an active participant of the greenhouse gas emissions governance.

iv) For Non-EU countries, compared the strategy of supporting EU to help establishing a good international aviation carbon taxation system and pay aviation carbon tax to the EU, absolutely, the potential economic benefits is far less than aviation carbon tax required to pay, that is $\varepsilon < \gamma$; At the same time, compared to the increasing cost of aviation carbon tax, the cost of the Non-EU countries opposition to the EU 's levying aviation carbon tax is also less than the cost of its supporting when the aviation carbon tax need to pay ,that is $\mu < \gamma - \varepsilon$.

Based on the complete information static game, we can consider the strategies of both EU and Non-EU countries. For EU countries, regardless of the Non-EU country's supporting or not, it will chose levying aviation carbon tax as its dominant strategy. Because $\beta - \alpha > 0$, $\gamma + \beta - \alpha > 0$. As a rational person, regardless of the non-EU countries oppose it or not, the EU will select to levying aviation carbon tax. For Non-EU Country, as a rational person, if EU chose to levy aviation carbon tax, its optimal decision is to oppose levying aviation carbon tax, Because$\mu < \gamma - \varepsilon$.

Therefore, in the case of complete information, the optimal strategy of Non-EU countries and EU countries in this static game is (against levying, levying). The outcome of this complete information static game kind of explains the current phenomenon of EU and Non-EU countries on the issue of aviation carbon taxation. The EU unilateral coercive to levy aviation carbon tax to Non-EU countries, Non-EU countries spare no effort to oppose to it, from Moscow Declaration to China, the United States, Saudi Arabia's introducing relative bill to prohibit their airline companies to participate in the EU's carbon emissions trading system ,these are the best

available evidence that non-EU countries oppose EU's imposition on aviation carbon taxation unilaterally.

2.2 Complete Information Dynamic Game

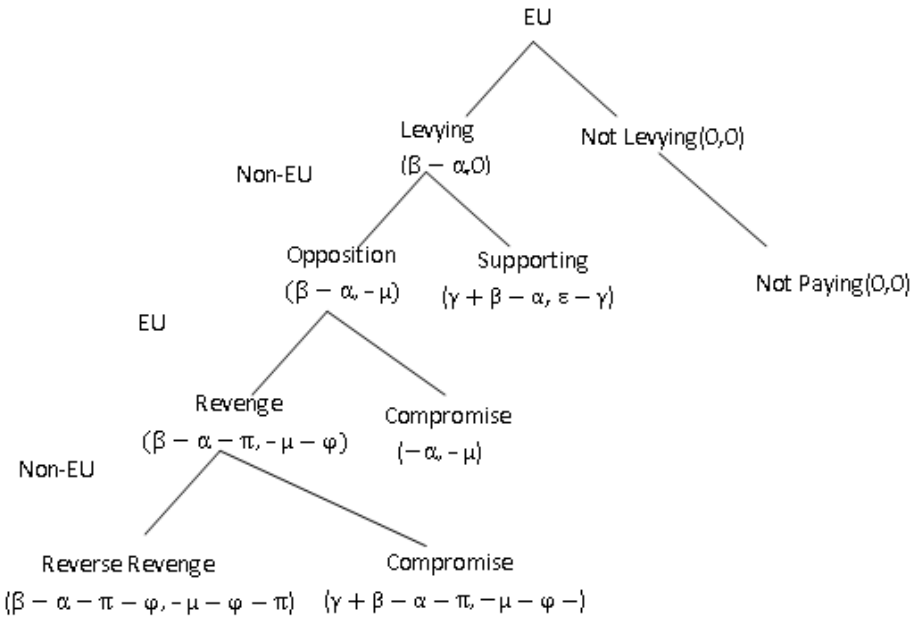
The above is the static game established between the EU and Non-EU countries in the case of complete information, next we will discuss the dynamic game in case of complete information situation.

2.2.1 Game Model Establishment

Assuming confront with the problem of levying aviation carbon taxation to Non-EU country, EU has two strategies, levying and not levying. There are two strategies for non-EU country, support levying (paying tax) and oppose levying (not paying). Facing with opposition from Non-EU country, the EU has to compromise or revenge. For EU's revenge, Non-EU country can also compromise or reverse revenge to EU Country.

Continue with the assumptions in complete information static game, we assume that after Non-EU country's opposition to levying aviation carbon tax, the EU and Non-EU countries' cost to revenge and reverse revenge are both π, their revenge will make the other player loss φ. So with complete information, the dynamic game expression as shown in figure 1 as follows. From the above picture, we can see that The game can be seen as a sequential game, in retaliation costs and the effectiveness of their own is not too large, the game will be unlimited carried out until any of the player choose to compromise. Actually retaliation and anti-retaliation between EU and Non-EU countries are just like that both of them are fighting fight a war of attrition which is a time-consuming game. Assumes that the EU and non-EU have no other strategies but revenge and compromise, here we ignore the situation that both agreed through ICAO agreement to solve the problem, then the purpose of the game lies in that shall Non-EU countries pay the aviation carbon tax or not.

Figure.1 The extended expression of complete information dynamic game



But in order to facilitate further analysis and to simplify the game model, assumes that the EU and non-EU countries are player x and y in the dynamic game on aviation carbon tax, and the value v (v> 1) are the disputed utility that both of them might get at any time t; While each time, if any of them insist on a turn, they will pay a cost of 1 for the game. The game between the two sides in each round has two options: {stop, do not stop} (ie {compromise, reverse revenge}). Throughout the course of the game, consider this sub game, that is, at a certain moment $\bar{t}$, at least one of them stop the battle (chose to compromise).So at $\bar{t}-1$ both

two sides are still competing for each other. $\bar{t}$ actually represents the end moments of the game, obviously both earnings can be a function of $\bar{t}$.

Assume that δ ($0<\delta\leq1$) represents the each round discount factor, player x are called pioneer If it stop first at $\bar{t}$,his earnings should be function as below：

$$L_x(\bar{t}) = -\left(1+\delta+\ldots+\delta^{\bar{t}-1}\right) = -\frac{1-\delta^{\bar{t}}}{1-\delta} \quad (1)$$

While for player x's opponents player y, his earnings should be functioned as ：

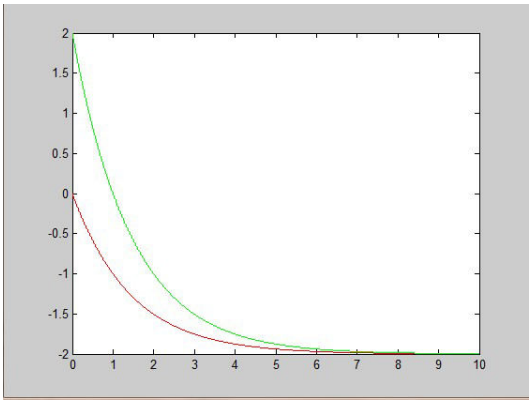
$$F_y(\bar{t}) = -\left(1+\delta+\ldots+\delta^{\bar{t}-1}\right) + \delta^{\bar{t}}v = L_x(\bar{t}) + \delta^{\bar{t}}v \quad (2)$$

Profit function (1) and (2) can also be said to be player y's earnings when both stop at $\bar{t}$.So, in the ensuing discussion, as long as there is a winner, $L(\bar{t})$represents the profitability of the losers, $F(\bar{t})$ represents the profitability of the winner who win v. If both stop at $\bar{t}$, we say that no one has won, the profitability of both sides are as follows:

$$B_1(\bar{t}) = B_2(\bar{t}) = L(\bar{t}) \quad (3)$$

Envisaged when the time interval fully short-term , the discrete type consecutive time in the form of a war of attrition, $L(t)$ and $F(t)$ Figure can be broadly described. Assumes "$\delta = 0.5$, $v = 2$." With Malab software mapping, graphs are as follows, where the red line is L (t) and the Green Line is F (t) (see Figure 2).

Figure 2 The Graphs of F(t) and L(t) while δ = 0.5, v = 2.



From the diagram we can see that, for any $0<\delta\leq1$, similarly, t=0, $F(t) = v > 0, L(t) = 0; t >$ 0 时 , $L(t) < 0; t \to +\infty$, $F(t) = L(t) < 0$.

The asymmetric Nash equilibrium: one party's strategy is to "never stop" (been retaliation), the other strategy is to "always stop" (always compromise). Of course, when a party has been stopped at t (compromise) on the game itself, and the other at the next moment on {stop, do not stop} ({compromise retaliation}) to select between seem pointless because the game has ended. This kind of Asymmetric Nash equilibrium is always that one side wins the game and the losers lost little. The game somewhat equivalent to the two "single-plank bridge on top cow first goes through the bridge. The "Frailty" always let "strong" first walk over the bridge is Nash equilibrium.

Back to reality, you can say that any party to the compromise will decrease their own utility and the other party will increase their own utility. Between the EU and non-EU aviation carbon tax problems of the game, Game asymmetric Nash equilibrium:

1. (Compromise, Revenge): EU compromise, the game stopped. Aviation carbon tax; revenge of non-EU countries of utility-based aviation should pay carbon tax and pay the difference between the cost of the EU loss should pay the costs for retaliation and non-EU countries.

2 (Revenge, Compromise): non-EU compromise, the game stopped. Retaliation for the cost of the effectiveness of the EU aviation carbon tax paid by non-EU countries and the European Union to pay the difference between the loss of non-EU countries in retaliation for the cost and pay to the EU aviation carbon tax.

Both the EU and non-EU countries will not be compromised in the current international situation, however, in order to reduce the aviation industry's greenhouse gas emissions, urgent introduction of multilateral consultative recognized global solutions. This, I believe that the game between the EU and non-EU will always continue.

3. Conclusions

In summary, the results of the game between the

EU and non-EU countries in the analysis process are just based on the final equilibrium assumptions and relevant parameters, and are not the actual game results. But that can reflect the game development trend. With the efforts of ICAO, the outcome of the game may also changes in the future. Worthy, regardless of the game, how, based on the world of the importance of greenhouse gases governance, the governance of the greenhouse gas emissions of the aviation industry will surely be resolved by aviation carbon tax levied. Many national standards and the starting point may be different. And the establishment trading market of aviation carbon emissions will only accelerate the EU's unilateral imposition of the countries in the world and the ICAO process, and build the foundation for the global aviation industry's carbon emissions trading market.

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