



Model and Analysis the Game Related to Economics Using Pure Strategy and Mixed Strategy: Evidence from Indonesia

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Abstract

The purpose of this paper is to construct model and analysis the game related to economics using pure strategy and mixed strategy. In this game, more than one people are involved and it proceeds as their preferences, every single strategic actions and the information are available to the other players. Each of these actions influence the outcome. Game theory deals with any problem in which each player strategy depends on what the other players do. This research uses the data from the conflict among the Central Government, Local Government, and WALHI (Indonesian environment forum) of Indonesia's haze pollution in Riau region. Analyzing preferences of each players using pure-mixed strategy, each player's preferences equilibrium met at central government delays to take any action regarding the haze pollution; local government modifies local regulation that can help reduce pollution; and WALHI does not protest because local government already wants to support them by modifying local regulation.

Keywords: Game Theory; Pure-Mixed Strategy; Decision Making Analysis.

1. Introduction

Palm oil is one of the world's most produced and consumed oil for it is cheap, production-efficient, and highly stable oil. Palm oil is widely used in a wide variety of food, cosmetic, hygiene product, and also can be used as source for bio-fuel or biodiesel. Indonesia is the largest producer and exporter of palm oil in the world, followed by Malaysia. Both of countries together account for around 85 to 90 percent of total global palm oil production.

Palm oil plantation and processing industry is a key industry to Indonesia's economy. The export of palm oil is an important foreign exchange and the industry provides employment opportunities for millions of Indonesians. Palm oil industry showed such a robust growth during this past 15 years. It is visible in the country's production and export numbers of palm oil.

According to the Indonesian Palm Oil Association (Gapki), Indonesia's Crude Palm Oil (CPO) exports are up to 21 percent to 23.9 million in the period of January-November 2015. 25 million tons are expected to be exported abroad in 2016, with the country's top CPO export markets in the USA, India, China, Eurozone, Bangladesh and Pakistan. In the first two months of 2016 Indonesia's palm oil exports reached 4.39 million tons, up to 22 percent from the 3.59 million tons of CPO that Indonesia exported in the same period one year earlier. The Indonesia's crude palm oil (CPO) exports rose 20 percent month-on-month to 2.09 million tons in April 2016 on the back of growing CPO demand in Africa, Bangladesh, India and the European Union.

The data from the Indonesian Ministry of Agriculture stated that the total area of oil palm plantations in Indonesia is currently around eight million hectares; a number which is twice as much as in the year 2000 when around four million hectares of Indonesian soil was used for palm oil plantations. This number is expected to increase to 13 million hectare by 2020. Almost 70 percent of Indonesia's oil palm plantation is in Sumatra (especially in Riau Province), the rest is largely found in Kalimantan.

The conflict is caused from the way farmers prepare their farm lands to plant. Many companies still use traditional way to clear land to make way for palm-oil plantations which is burning forests. Companies use this method because it is cheap and fast compared to other methods. It caused smog and air pollution. Three main parties started to raise their voices. The local government wants to regulate those farmers for they are the party directly involved in the pollution. However the central government of the country wants to delay the enactment of the regulation for the industry is the key industry for the country. On the other side, WALHI, Indonesia Forum for Environment, they protest the government for the issue.

2. Introduction to Game Theory

Game theory was founded by mathematicians John von Neumann in 1944. Game theory applies whenever the actions of several agents are interdependent. Therefore the main aim of game theory with more emphasis on the dominance, Nash equilibrium, max and min Strategies, mixed strategies, extensive games with perfect information, extensive games with imperfect information, zero-sum games and computation, and lastly on the bidding in auctions. In this report we only use the Nash equilibrium and Conflict analysis

The purpose of studying game theory is learn how a decision is made when there is conflict between multiple numbers of decision makers. In a game there are more than one people involved and arranged in their preferences, every single strategic actions and the information are available to the players. Each of these action influence the outcome. These techniques apply to more than just sport, and are not even limited to competitive situations. In short, game theory deals with any problem in which each player strategy depends on what the other players do. Game theory is generally divided into two branches, which are non-cooperative and cooperative game theory. It is defined as a non-cooperative game, when players are unable to communicate with one another. When players can communicate, the game is considered as a cooperative game

In this paper, the game is assumed as a non-cooperative game which focuses on strategic choices resulting from interaction among competing players, each player choose its strategy independently for improving its own satisfaction. Non-cooperative game theory means, players make choices out of their own interest. The model of non-cooperative game theory the details of the ordering and timing of players' choices are important in determining the outcome of a game. Several concepts such as the Nash equilibrium exist for solving non-cooperative games.

2.1 NASH Equilibrium

This concept is widely used in the game theory by predicting the outcome of a strategic interaction in the social sciences. A game which in form of either strategic or normal consists of the following three elements: a set of players, a set of actions or pure-strategies available to each player, and a payoff (or utility) function for each player. The payoff functions represent each player's preferences over action profiles, where an action profile is simply a list of actions, one for each player.

A pure-strategy Nash equilibrium is an action profile with the condition that no single player can obtain a higher pay off by crossing the line from this profile. The Nash equilibrium is normally applied in economics Nash equilibrium was introduced by John Nash in 1950 and has emerged as one of the fundamental concepts of game theory.

Nash equilibrium is a solution concept of a game involving two or more players, in which each player is assumed to know the equilibrium strategies of the other players, and no player has anything to gain by changing only his own strategy. However, concept of equilibrium is one of the most important and elegant ideas in game theory.

Nash equilibriums, and some of these equilibriums may be unreliable compared to what should be the outcome of a game. Some studies reflect that Nash equilibrium is concern about the actions that will be chosen by players in a strategic game. Players have to know precisely what their opponents will choose. To do so, players should not base on the assumption that all players are rational, but focus on the basis of statistical information about previous game playing situations, if such information is available and reliable.

2.2 GMCR II Software

GMCR II (Graph Model for Conflict Resolution, Decision Support System II) constitutes the next generation of a strategic decision support system. It effectively and efficiently examines strategic conflicts that take place in many areas. As demonstrated by many real world applications, GMCR II can provide decision makers and analysts with decision advice, structural insights and answers to what-if questions. With this enhanced understanding, analysts can better explain strategic relationships and assist decision makers, who may have the opportunity to direct the evolution of the conflict toward more favorable results.

3. Case Background

The rapid growing development of palm oil industries in Indonesia has been criticized by environmentalist group for resulting in deforestation and destruction of carbon-rich peat lands. Many companies still use traditional way to clear land to make way for palm-oil plantations which is burning forests. Companies use this method because it is cheap and fast compared to other methods.

This air pollution caused by burning land has become a problem since a long time ago and repeated annually. About half of the fires burn on plantations are owned by big palm-oil and logging corporations. Law itself still allows palm oil companies to burn forests for clearing their planting land. The law just restricts the size of areas they can burn.

The worst condition happened in 2015. Indonesian government already declared haze emergency in Riau as pollution from raging forest fires hit highly hazardous level. Pollutant Standards Index (PSI) above 300 is considered as 'hazardous', meanwhile Riau's PSI reached 984 at highest.

Based on data available with Indonesia's National Disaster Mitigation Agency (BNPB) for 2015, at least there are 79,888 people in Riau have already been treated for respiratory, eye or skin problems. Every year more than thousands of people needed medical treatment for respiratory problem. Haze pollution also has disrupted economic activities, schools was closed, most of flights were canceled, and even more it caused at least 5 people died in 2015. Recorded by Indonesia's National Disaster Mitigation Agency, the total loss because of haze pollution in Riau reached 150 million US dollar.

Looking at this environmental problem, Indonesia's largest environmental NGO Wahana Lingkungan Hidup (WALHI), or the Indonesian Forum for Environment, which is part of the Friends of the Earth network, started to move. They planned to sue companies which indicated burning forests and land. WALHI also demanded Indonesia's government to end this haze pollution which always happens every year and harms citizens' right to get healthy environment. One of the ways to end this haze pollution is modifying the regulation which still allows burning forests as method to clear planting land.

4. Construction for the Model

To construct a game model, there should be players. For manufacturers are obliged to abide by the law and regulations, three players have been chosen as below

i) **Central Government**

Option: Delay

Central government is chosen for they can revise the regulation immediately for all nation to forbid palm oil companies to use burning land method. But central government doesn't take any action until now. So it means central government has delay revising regulation as an option.

ii) **Local Government**

Option: Modify

Local government in Indonesia has privilege to make or modify regulation for their province. Since the haze pollution is happening in Riau province and the province itself who suffered with immediate effects, local government can modify local regulation to ban burning land method for palm oil companies. So the option that local government has is modify regulation.

iii) **WALHI**

Option: Protest

As Indonesia Forum for Environment, which concerns about environments, the party protests to government for burning land method leave serious damage to environment. WALHI is going to pushed government to enact regulation to forbid burning land method through protesting. So WALHI's option is to protest.

The game is proceeded by pure-mixed strategy method to get equilibrium state for this case by using Gambit software. To compare the result, GMCR II software is also use to analysis for conflict analysis with the same data.

Before constructing the model for pure-mixed strategy, preference information for each Decision Making Unit can be summarized as the following table to help us to understand each party's interest. The preference information was built based on information from newspaper articles.

| Table 1: Decision Makers and Preferred Options | | |
|--|----------|--|
| DMU | Value | Preference Interpretation |
| Central Government (CG) | 1 | CG wants delay the regulation |
| | -2 | CG doesn't want LG modify |
| | -3 | CG doesn't want WALHI to protest |
| Local Government (LG) | 2 | LG want to modify the regulation |
| | -1 | LG doesn't want CG to delay the regulation |
| | -3 | LG doesn't want WALHI to Protest |
| WALHI | 2 | WALHI wants LG to modify |
| | -3 IFF 2 | WALHI doesn't want to protest if LG modify |
| | -1 | WALHI doesn't want CG to delay |

4.1 Model for a Pure-Mixed Strategy

| Table 2: Decision Makers and Preferred Options For A Pure-Mixed Strategy | | | | | | | |
|--|-------------|------------------|----|----|------------|----|----|
| | | Local Government | | | | | |
| Central Government | WALHI | Modify | | | Not modify | | |
| Delay | Protest | -1 | -1 | -1 | 1 | -1 | -3 |
| | Not Protest | 1 | 1 | 1 | 3 | -3 | 1 |
| Not Delay | Protest | -3 | 1 | 1 | -1 | 1 | -1 |
| | Not Protest | 1 | 3 | 3 | 1 | -1 | 1 |

To construct a good model, it is crucial to choose right decision makers and their choices. In the model, it has been chosen Central Government which can decide either they modify related regulation which applied whole nation or not, Local Government which can only decide whether they modify provincial regulation or not, and WALHI, Indonesian forum for environmental issues which can either protest about the issue or not. In this model, producers, and neighbor countries are excluded for it is considered that all the firms in Indonesia will have to either follow the regulation or not, and neighbor countries might affects decision makers decision but still the decision is on the decision makers which has been chosen.

While constructing this model, giving value for each outcome's benefit or loss of each player was a complicated task, so it is assumed that all payers start with zero condition and when each of decision maker makes preferred decision, a point is added, and deducted a point when any player including decision maker herself make unfavorable choice according to preference table which is made according to news articles.

4.2 Model for Conflict Analysis

The option form from the option that each Decision Making Unit has is below. After removing the infeasible, eight states can be possible results.

| Table 3: Option Form of The Model | | | | | | | | |
|-----------------------------------|----|----|----|----|----|----|----|----|
| CG (Delay) | N | Y | N | Y | N | Y | N | Y |
| LG (Modify) | N | N | Y | Y | N | N | Y | Y |
| WALHI (Protest) | N | N | N | N | Y | Y | Y | Y |
| State Number | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 |

5. Results for this Model

5.1 Result for Pure-Mixed Strategy Model

| Table 4: Equilibrium State | | | | | |
|----------------------------|-----------|------------------|------------|---------|-------------|
| Central Government | | Local Government | | WALHI | |
| Delay | Not Delay | Modify | Not Modify | Protest | Not Protest |
| 1 | 0 | 1 | 0 | 0 | 1 |
| 0 | 1 | 1 | 0 | 0 | 1 |

According to Gambit software, two pure strategy equilibrium was found at state 4(delay, Modify Regulation, Not Protest); and state 3(Modify Regulation, Modify Regulation, Not Protest). In these outcomes, the benefits of each player are: (1, 3, 3) and (1, 1, 1). No mixed strategy was found.

5.2 Result for Conflict Analysis Model

Table 5: Central Government (CG) Preference

| DMs | Options | 2 | 6 | 4 | 8 | 1 | 5 | 3 | 7 |
|---------|------------|---|---|---|---|---|---|---|---|
| central | 1. delay | Y | Y | Y | Y | N | N | N | N |
| local | 2. modify | N | N | Y | Y | N | N | Y | Y |
| WALHI | 3. protest | N | Y | N | Y | N | Y | N | Y |



S2>S6>S4>S8>S1>S5>S3>S7

Table 6: Local Government (LG) Preference

| DMs | Options | 3 | 7 | 4 | 8 | 1 | 5 | 2 | 6 |
|---------|------------|---|---|---|---|---|---|---|---|
| central | 1. delay | N | N | Y | Y | N | N | Y | Y |
| local | 2. modify | Y | Y | Y | Y | N | N | N | N |
| WALHI | 3. protest | N | Y | N | Y | N | Y | N | Y |







S3>S7>S4>S8>S1>S5>S2>S6

Table 7: WALHI Preference

| DMs | Options | 3 | 4 | 7 | 8 | 5 | 6 | 1 | 2 |
|---|--|---|---|---|---|---|---|---|---|
|  central |  1. delay | N | Y | N | Y | N | Y | N | Y |
|  local |  2. modify | Y | Y | Y | Y | N | N | N | N |
|  WALHI |  3. protest | N | N | Y | Y | Y | Y | N | N |

S3>S4>S7>S8>S5>S6>S1>S2

Table 8: Equilibrium State

| DMs | Options | | 4 | 8 |
|---|--|---|---|---|
|  central |  1. delay | — | Y | Y |
|  local |  2. modify | — | Y | Y |
|  WALHI |  3. protest | — | N | Y |

According to GMCR II software, two equilibrium states was found at State 4 and State 8. S4 means Central Government delays, Local Government modifies regulation, and WALHI does not protest. S8 means Central Government delays, Local Government modifies regulation, and WALHI protests.

6. Analysis of the Model

6.1 Analysis for Pure-Mixed Strategy Model

Based on the result from Gambit 15 software, two equilibriums satisfying all Decision Making Unit are found. First equilibrium at Central Government delays, Local Government modifies, and WALHI not protests. This is acceptable for all Decision Making Unit for Central Government still delays to take action as its preferred option, Local Government can modify the local regulation to reduce immediate damage caused by pollution, and WALHI also gets support to protect environment since Local Government modifies local regulation.

Another equilibrium at Central Government does not delays, Local Government modifies, and WALHI does not protest. This is also preferable for all Decision Making Unit. Central Government does not delay to take action for the pollution disturbs not only economic activities but also diplomatic relationship with countries near Indonesia such as Singapore. Local Government accepts this equilibrium because they can modify the local regulation to reduce immediate local damage because of haze pollution. WALHI also accepts this equilibrium because they get support to protect environment from Central Government who does not delay to take action and from Local Government who modifies the local regulation to protect environment.

6.2 Analysis for Conflict Analysis Model

Same as the result obtained from Gambit 15 software, two equilibrium states for all Decision Making Unit are found from GMCR II software. First equilibrium is at State 4 which is Central Government delays, Local Government modifies, WALHI not protests. This is acceptable for all Decision Making Unit because Central Government gets what it wants, which is delaying to take action, Local Government gets what it wants by modifying the local regulation, and WALHI also gets some of what it wants through Local Government modifies local regulation.

Another equilibrium is at State 8 which is Central Government delays, Local Government modifies, and WALHI protests. This is acceptable for all Decision Making Unit because Central Government gets what it wants, which is delaying to take action, Local Government gets what it wants by modifying the local regulation, and WALHI still does protest cause of delaying by Central Government.

6.3 Comparison between Pure-Mixed Strategy Result and Conflict Analysis Result

Both of pure-mixed strategy result and conflict analysis result shows similar result for equilibrium states. The equilibrium state that showed at pure-mixed strategy result and conflict analysis result is Central Government

delays, Local Government modifies, and WALHI not protest. There are reasonable conjecture how these equilibrium state is found.

First, Central Government will delay because Central Government needs to think about Indonesia's economy. If Central Government takes any action immediately, such as making new regulation for forbidding the burning land clearing method, maybe many palm oil companies will close down their business. It's because using another method to clear land will cost more for palm oil companies. If palm oil companies think they can't fulfill the regulation, they would choose to take down their business. Indonesia will lose many export value if it happens and unemployment rate will increase.

Second, Local Government will modify the local regulation because Local Government needs to think the direct and immediate disadvantage effects for Riau because of the pollution. It already caused many public sectors to be closed for days, such as schools, airports, and public offices. Besides that, many Riau local citizen already infected by many diseases caused of the pollution, such as respiratory problems. Those disadvantages of course lead to millions of financial loss and disturb local economy activities.

Last, WALHI will not protest because Local Government already agrees to modify local regulation about the burning land clearing method. By modifying local regulation, it can help to reduce the pollution to be happen in future and it can protect the environment, which those are WALHI's purpose.

7. Conclusion and Future Work

After studying the goals of each decision makers, most preferred results are found. Central government of Indonesia which has to consider economic growth of the nation would want the result which they delay, modifying the regulation and local government to not change their regulation nor WALHI to not protest. For Local Government, for they are facing real problem of the pollution, they would prefer the outcome that they modify the regulation, Central Government to modify the related regulation so other local government to follow, then WALHI stay calm. For WALHI, they first would want Local Government to modify their provincial regulation, for it regulates in front line. Then they will decide whether they will protest or not then they want Central Government to modify regulation which applies to whole country.

Applying, pure strategy, most preferable outcome is Central government to delay, Local Government to modify provincial regulation, and WALHI to not protest. Under this outcome, Central Government can let each local government to decide whether they will modify or not, and reduce the negative effects of reducing palm oil production on Indonesia's economy. The Local governments also can have ability to control pollution. WALHI too will satisfy their goal which is reducing air pollution and saving the forest.

During studying this case, it is not an easy job to determine right value for each alternative options. Therefore, the benefit of each move had to be assumed under two assumptions that are: all three decision makers' state is 0; and each preferred decision brings 1 value and deducted 1 when either other party or decision maker herself makes undesirable choice. This assumption might have led the study to unrealistic outcome. In the future work, if it is possible, one can measure those values in either monetary value or in its special measure.

Another weakness of the work is that in order to simplify the model, number of decision makers had to be limited. In real world, there are not only 3 decision makers related with this issue but more. There are palm oil producers, citizens of the region, and neighbor countries. There are not only decision makers but factors which can affect the decision makers such as diplomatic friction with neighbor countries, economic condition in country or region, and so on. The last suggested future work is trying this case in sequential or cooperative game. For all three organizations are cooperating and their decision effects each other's, it is essential to consider the relationship between the three organizations and choose the order which group will decide first.

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