SOCIOLOGICAL STRATEGIES IN INDONESIAN MINING SITE: THE PRISONER DILEMMA APPROACH

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Abstract

The study of the social system in Indonesian mining site needs a unique approach as the social system there cannot be categorized easily as urban or even rural society. It is obvious that in the mining site sociology we can model the three main role-players: regional government, mining corporation, and society surrounding the mining site, as 3IPD while the three of it tends to be non-cooperative. The simulation using this idea can bring to the optimization of the strategy that can be taken by those agents since holistic sustainability is very important to the whole system. The simulation in each module preserved: politically, economically, environmentally, and culturally, it is obvious that the system tends to the class differentiation and temporary differentiation. It is possible to gain further and advanced analysis by using primary data collecting.

Keywords:
Prisoner dilemma, 3IPD, mining society, mining corporation, regional government, social system, complex adaptive system, self-organized system.

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1. Introduction

The existence of mining corporations in Indonesia has brought some distinct sociological impacts in the mining site that some conventional sociological approach will not deserved to answer the sociological challenges. The mining corporations in Indonesia open remote area to become the mining site that the rural places need to provide temporary accommodation for new administration. In Indonesia, the exploitation and the whole mining activities in the rural places has turned the rural site to be a mining town that is not self-contained world as should be. The arrival of the mining corporation tends to build mining-site has been constituted a more visible presence of government authority in the area (Garza:2000). This fact is caused by the unique sociological ethnography that showed how society has been constituted around the mining site. The place that shall not be categorized urban while the facilities in the mining site are civilian town-like, but not also can be categorized rural as the remote area of the mining site.

On the other hand, the people that live in the surrounding of the mining site is often the origin and retarded people far away from the modernization. These people are often live in colony with traditional law and the arrival of the big mining corporation in order to exploit the natural resources professionally there often emergent some conflicts or social restless. Thus, the settlement surrounding the mining town will face some sociological problems, and again, the conventional sociological approaches will not fit (King:1978).

Moreover, some actual changes in structures of political powers in Indonesia has brought some more problems to solved. Since the declining of the New Order Regime in Indonesia, the need for decentralization of governmental policies has been voiced. The Law No.22/1999 about the regional governance has stated the local governments in Indonesia the authority to act as autonomous regions. This is very different with the old counterpart, the centralized government in Soeharto era (Rhee:2000).

This paper will analyze the social conditions there by using computational simulations or models using the prisoner dilemma model as a top-down modeling perspective. In this paper, we will use two approaches modelling on Prisoner Dilemma: The Iterated Prisoner Dilemma (IPD) and The Three Players Iterated Prisoner Dilemma (3IPD).

It is obvious that there are at least three main agents in Indonesian mining site. The first agent is the mining corporation, the second one is the local government concerning the actual regional autonomy, and the third is the people living surrounding the mining town powered by the non-governmental organizations may exist.

We use the IPD while analyzing the connections or communications between two agents: society with regional government, regional government with the mining corporation, and the mining corporation with the society. The second approach is by using the 3IPD to have a view on how the three agents co-evolving respectively.

We will use the perspective: society as complex adaptive system, and we will show how the three agents above evolve by using self-organized mechanism. In the end of the paper, we will be able to use this approach for some suggestions of strategies that the agents can do in order to gain the highest sustainability.

2. The Iterated Prisoner Dilemma

The Prisoner's Dilemma is a simple two-person game, where each player (for instance two prisoners accused of the same crime) can choose either to cooperate (C) or to defect (D = not cooperate).

Table 1 shows the payoff matrix: if one player defects, the other has the option to cooperate yielding S (the sucker's payoff or to defect and obtain P (the punishment for mutual defection). On the other hand. if the opponent cooperates, one receives R (the reward for cooperation) for a C or gains T (the temptation to defect) for a D. Provided the payoffs satisfy

$$T>R>P>S, \text{ with } R>(S+T)/2$$

and the players meet only once, each player should defect no matter what the adversary does, in order not to become the 'sucker'. In a population of interacting pairs of individuals as described above, no single mutant adopting a different strategy can invade and secure a foothold. Defection is the primeval state and the only evolutionary stable strategy. However, when played repeatedly, there is no trivial answer to the question of how cooperation can arise from an non-cooperative state. (Brembs:1996).

The Iterated Prisoner Dilemma (IPD) is the game has been extensively analyzed from many perspectives in the social and computational sciences and is now fairly well known in the general intellectual community (Axelrod:1984).

The dilemma is fundamental to social life: how to sustain over time a pattern of cooperation between agents that may be quite beneficial to both, when in the short run it is always in the interest of each agent to defect, no matter what action the other agent may take. To build the model, we shall systematically investigate the effects of variations in three key dimensions, i.e.: the strategy space from which the agents' strategies are selected, the interaction processes that channel agents into interactions with some agents and away from the interactions with others, and the adaptive process that govern the changes in agents' strategies over time (Axelrod, Cohen, & Riolo:1998).

		Player 2	
		Cooperate	**Defect**
Player 1	**Cooperate**	R=3	S=0
	Defect	T=5	P=1

Table 1.
The Classical 2 Player Prisoner Dilemma Payoff Matrix. Each player corresponds to the score of Player 1 and Player 2 respectively.

Computer tournaments of IPD programs were organized by Axelrod, where each player has a strategy depending on each history. The most successful strategy therein was the well-known Tit-For-Tat (TFT), which cooperates in the first move and plays whatever the other player chose on the previous move. When the evolution of strategy is included, cooperation prevails in society, without any explicit indication, through the success of the TFT algorithm. Thus the emergent society is cooperative, in which the strategies therein are very simple and basically uniform by players.

3. The Three Players Iterated Prisoner Dilemma (3IPD)

Dealing with 3IPD, we will meet some significant differences here. In the 3IPD, we will deal with three players and the pay-off function along the rounds and tournaments among them will depend upon the coalition that raised in the game, as their action whether to cooperate or to defect the whole localized social system. We will modify the Akiyama and Kaneko modeling method in this simulation, as defining the rules for the three-person game as follows:

1. Each player must hand in either card 0 (cooperation) and card 1 (defection).
2. If two players hand in the same cards, they are regarded as forming subgroup (coalition) and gain score (1). A player excluded from the sub-group cannot gain any score, and either if all the three players hand in the same cards they cannot get any score (Akiyama & Kaneko:1995).

In easier view of payoff function to each players is settled in table 2. Here we distinguish left or right player, assuming that the three players are located in a circle so that each player has a right and left player. We can see obviously the symmetry of the game rules while distinct with the 2 player counterpart.

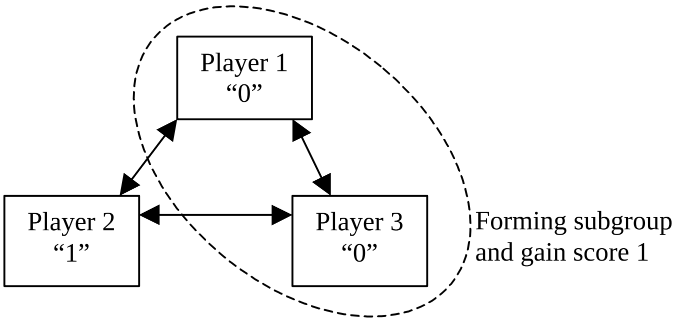

Figure 1.
Forming the sub-group or coalitions and gain score.

State	Left	Right	You	Score
0	0	0	0	**0**
1	0	0	1	**0**
2	0	1	0	**1**
3	0	1	1	**1**
4	1	0	0	**1**
5	1	0	1	**1**
6	1	1	0	**0**
7	1	1	1	**0**

Table 2.
Payoff matrix of 3IPD coalition game. The number 0 and 1 in column 2,3, and 4 represents the action that taken by each player. In this case, 1 represents defection, and 0 represents cooperation respectively. Here we can seem that if and only if your state is between 2 and 5, you are in a subgroup and gains score.

Rule of Akiyama 3 IPD arithmetically can also be generated from the following explanation. The payoff of an agent is represented by value of each coalition with other agent against another agent excluded of the coalition. For example,

Payoff of A = coalition of A and B against C + coalition of A and B against C.

Value of coalition of one agent with other agent against another agent can be divided in to two elements valued of closeness of the agent and coalition agent and value of separation with the opponent agent. Hence the above equation can be extracted to:

Payoff of A = [(value of closeness between A and B) multiplied with (value of separation between A and C)]+ [(value of closeness between A and C) multiplied with (value of separation between A and B)]

Each action of A,B and C is represented by σA,σB and σC and each payoff of A,B and C is represented by ρA, ρB and ρC. Then one form of the last equation is

$$rA = \left(1 - \left|sA - sB\right|\right) * \left|sA - sC\right| + \left(1 - \left|sA - sC\right|\right) * \left|sA - sB\right|$$

where:

$\left(1 - \left|sA - sB\right|\right)$ =Value of closeness between A and B

$\left(1 - \left|sA - sC\right|\right)$ =Value of closeness between A and C

$\left|sA - sC\right|$ =Value of separation between A

$\left|sA - sB\right|$ =Value of separation between A and B

Then we can see the last equation as the rule of Akiyama 3 IPD.

3. Implementation of the Model

From the problem identifications that emerged in the interactions among the agents in the society in mining site, we have to figure out the *pay-off* each player can gain for each strategy they carry out. In our simulation, action taken by each agent is made at scale 1 to 0, which means to *cooperate* and to *defect*, respectively. Deciding what strategies carried out by each agent, whether it is to *cooperate* or to *defect*, each agent obviously has own considerations.

The considerations made by each agent will depend on variables and parameters prevailed in the mining system. From those variables and parameters, we can make several *functions* that regulate the relationship among the agents. In mathematical notation, the *function* can be expressed as follows:

$$f(a,b,c,d,\ldots,t)$$

where *a,b,c,d* are variables in which *function* with *t* is time parameter. The variables prevailed in the mining system could be economical, political, socio-cultural, or environmental variables. Then, the *action function* of each agent can be expressed in the following:

$$\delta_{ij} = \begin{cases} 1, \text{ if } f(a,b,c,d,\ldots,t) \geq k(t), \\ 0, \text{ else} \end{cases} \quad ij \ne ji$$

where d_{ij} defines the action taken by agent *i* relative to agent *j*. Constant *k* is defined concerning to the survey result that shall be done to complete this research[*)]. In this case, the action that is taken by agent *i* relative to agent *j* does not fulfill the commutative law. In this paper, we use the notation for each agent as follows:

[*)] In this paper, due to lack of data because we do not make surveys, the value of *k* determined according only to secondary data. Hence, the value of *k* does not represent the real situation in the ongoing mining-site system. The value of *k* here is only to show the strength of this simulation method..

Mining Corporation = agent *x*
Society (the people surrounding the mining site) = agent *y*
Regional Government = agent *z*

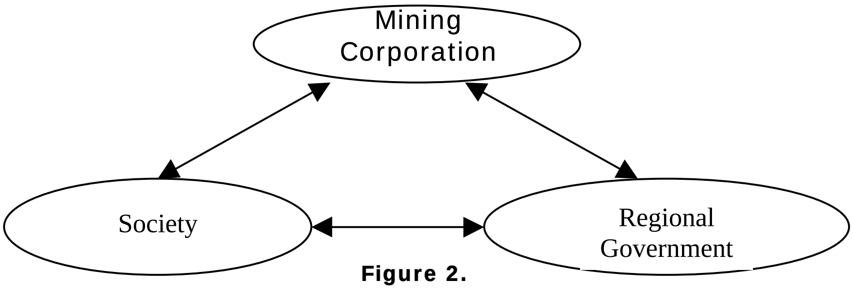

Figure 2.
The three interacting agents in mining site society- every interactions between two agents simulated by the IPD.

To make it easy the computational and analysis process, the problems emerged in the mining site divided into several sub-problems, such environmental, economical, political and socio-cultural problems. Each sub-problem will be explained as follows:

3.1 Economical Sector

In economical analysis, all agents in the mining site are grouped as follows :
In this economical analysis, we do not treat large-scale and small-scale corporation as the same agent, instead we place the small-scale corporation as part of the society. We do this concerning the differentiation in their economic action and behavior, such as capital size, pattern of production and distribution, and management. In the following, we will explain the economic interaction among agents in the mining site.

3.1.1 Action made by Large-scale corporation (LSC) relative to the society (people surrounding the mining site), and vice versa, in *cooperate* condition.

LSC to Society	Society to LSC
x1. Ratio between labor coming from local people and labor coming from elsewhere is large x2. The number of labor from local neighborhood is large compared by the number of work force in the mining site district x3. Salary of employee, especially employees that coming from local neighborhood is bigger than local living cost x4. Provide adequate fun for local community development x5. Develop infrastructure needed by local society x6. Make land reclamation and rehabilitation in ex-mining site	y1. Provide their land to the mining corporation if needed y2. Willing to be employee in mining corporation y3. Willing to be actor of economics that the products needed by the mining corporation

For *defect* condition, actions taken by the agent are negation of the actions mentioned above.

From those conditions, we can make *action function* of the interaction between those two agents in the following:

action function of LSC's action relative to the society (people)

$$\delta_{xy} = \begin{cases} 1, & f(x1,x2,x3,x4,x5,x6) \geq k_{xy}(t) \\ 0, & \text{else} \end{cases}$$

action function of Society's action relative to the LSC

$$\delta_{yx} = \begin{cases} 1, & f(y1,y2,y3) \geq k_{yx}(t) \\ 0, & \text{else} \end{cases}$$

3.1.2 Action made by LSC relative to the Government, and vice versa, in *cooperate* condition

LSC to Government	**Government to LSC**
x7. Pay taxes honestly x8. Pay royalties honestly X6. Make land reclamation and rehabilitation in ex-mining site	z1. Provide infrastructure needed by mining activities z2. Provide good service for bureaucracy and administration business needed by the corporation z3. Issued low taxes and royalties z4. Do not take illegal tax from the corporation

For *defect* condition, actions taken by the agent are negation of the actions mentioned above.
From those conditions, we can make *action function* of the interaction between those two agents in the following:

action function of LSC's action relative to the government

$$\delta_{xz} = \begin{cases} 1, & f(x6,x7,x8) \geq k_{xz}(t) \\ 0, & \text{else} \end{cases}$$

action function of government's action relative to the LSC

$$\delta_{zx} = \begin{cases} 1, & f(z1,z2,z3,z4) \geq k_{zx}(t) \\ 0, & \text{else} \end{cases}$$

3.1.3 Action made by the Government relative to the society, and vice versa, in *cooperate* condition

Government to Society	**Society to Government**
z5. Provide good public service including health, education, physical infrastructure, etc to the society z6. Do not take illegal taxes from the people in Society	y4. Pay taxes honestly and right at the schedule y5. Take care the public properties y6. Help government in developing public service and properties

For *defect* condition, actions taken by the agent are negation of the actions mentioned above.

From those conditions, we can make *action function* of the interaction between those two agents in the following:

action function of government's action relative to the society

$$\delta_{zy} = \begin{cases} 1, & f(z5,z6) \geq k_{zy}(t) \\ 0, & \text{else} \end{cases}$$

action function of society's action relative to the government

$$\delta_{yz} = \begin{cases} 1, & f(y4,y5,y6) \geq k_{yz}(t) \\ 0, & \text{else} \end{cases}$$

3.2. Political Sector

In political analysis, all kinds of mining corporation are grouped as one agent. This is under consideration that in the political perspective, especially in state administration, generally, the regulations issued by the government for any kind of mining companies are the same, or at least, similar. However, in fact there will be different weights of each player in influencing the government policy. Though this difference influence is out of our research area, but if in the survey we find out that this difference is big enough in influencing the social system in mining site, we will include it as variable or parameter.

3.2.1 Action made by Mining Corporation relative to the society (people surrounding the mining site), and vice versa, in *cooperate* condition

Mining Corporation to Society	Society to Mining Corporation
x9. Provide access to people in neighborhood to use facilities owned by the corporation x10. Engage coordination with NGO and people along with government in discussions of problems and solutions of mining cases	y7. Do not make any effort to impede mining activities such as demonstration, blockade, etc

For *defect* condition, actions taken by the agent are negation of the actions mentioned above.
From those conditions, we can make *action function* of the interaction between those two agents in the following:

action function of Mining Corporation's action relative to the society (people)

$$\delta_{xy} = \begin{cases} 1, & f(x9,x10) \geq k_{xy}(t) \\ 0, & \text{else} \end{cases}$$

action function of Society's action relative to the LSC

$$\delta_{yx} = \begin{cases} 1, & f(y7) \geq k_{yx}(t) \\ 0, & \text{else} \end{cases}$$

3.2.2 Action made by LSC relative to the Government, and vice versa, in *cooperate* condition

Mining Corporation to Government	Government to Mining Corporation
x11. Adhere all law and regulation issued by the Government X7. Pay taxes honestly and right in schedule X8. Pay royalty honestly and right in schedule	z7. Improve bureaucracy performance in giving public service z8. Do not Issue law and regulation that impede the mining activities Z3. Issued low taxes and royalty

For *defect* condition, actions taken by the agent are negation of the actions mentioned above.
From those conditions, we can make *action function* of the interaction between those two agents in the following:

action function of LSC's action relative to the government

$$\delta_{xz} = \begin{cases} 1, & f(x7,x8,x11) \geq k_{xz}(t) \\ 0, & \text{else} \end{cases}$$

action function of government's action relative to the LSC

$$\delta_{zx} = \begin{cases} 1, & f(z3,z7,z8) \geq k_{zx}(t) \\ 0, & \text{else} \end{cases}$$

3.2.3 Action made by the Government relative to the society, and vice versa, in *cooperate* condition

Government to Society	Society to Government
z9. Improvement of public service and public facilities z10. Facilitate well in public opinion and participation z11. Loose the regulation for widening the people's chances to run business, e.g. get loan from the bank	y8. Adhere the regulation issued by the government y9. Do not make any demonstrations or riots y10. Make pro-active participation in governance system

For *defect* condition, actions taken by the agent are negation of the actions mentioned above.
From those conditions, we can make *action function* of the interaction between those two agents in the following:

action function of government's action relative to the society

$$\delta_{zy} = \begin{cases} 1, & f(z9,z10,z11) \geq k_{zy}(t) \\ 0, & \text{else} \end{cases}$$

action function of society's action relative to the government

$$\delta_{yz} = \begin{cases} 1, & f(y8,y9,y10) \geq k_{yz}(t) \\ 0, & \text{else} \end{cases}$$

3.3 Enviromental Sector

The group is made under consideration that the miners, whether it is the large-scale, small-scale corporation or artisanal miner, all make the exploitation on the mine resources. Consequently, they all make environmental impact. At this kind of circumstances, we group all enterprises, regardless to their scale, as one agent.

3.3.1 Action made by Mining Corporation relative to the society (people surrounding the mining site), and vice versa, in *cooperate* condition

Mining Corporation to Society	Society to Mining Corporation
x12. Focus Environmental issues action on major risks and consequences x13. Strengthen reclamation bond program x14. Identify and target potential trouble spots for extra monitoring and enforcement x15. Engage with government and NGO in educate public on environmental and health dimensions of mining x16. Engage with government, NGO and society as well in handling environmental problems caused by mining activities X6. Make land reclamation and rehabilitation in ex-mining site x17. Research on elements of good practices in reclamation of mining land	z11. Willing to joint the environmental activities held by the corporation such as training, land reclamation and rehabilitation program

For *defect* condition, actions taken by the agent are negation of the actions mentioned above.
From those conditions, we can make *action function* of the interaction between those two agents in the following:

action function of Mining Corporation's action relative to the society (people)

$$\delta_{xy} = \begin{cases} 1, & f(x6,x12,x13,x14,x15,x16,x17) \geq k_{xy}(t) \\ 0, & \text{else} \end{cases}$$

action function of Society's action relative to the LSC

$$\delta_{yx} = \begin{cases} 1, & f(y11) \geq k_{yx}(t) \\ 0, & \text{else} \end{cases}$$

3.3.2 Action made by LSC relative to the Government, and vice versa, in *cooperate* condition

Mining Corporation to Government	Government to Mining Corporation
x18. Focus Environmental issues action on major risks and consequences x19. Strengthen reclamation bond program	z12. Loose the environmental regulation especially that which have direct relation with mining activities z13. Improve role defined and

x20. Identify and target potential trouble spots for extra monitoring and enforcement x21. Engage with government and NGO in educate public on environmental and health dimensions of mining x22. Engage with government, NGO and society as well in handling environmental problems caused by mining activities X6. Make land reclamation and rehabilitation in ex-mining site x23. Research on elements of good practices in reclamation of mining land	coordination among environmental agents in the government body z14. Expand environmental training programs for miners, especially for Artisanal Miners

For *defect* condition, actions taken by the agent are negation of the actions mentioned above.
From those conditions, we can make *action function* of the interaction between those two agents in the following:

action function of LSC's action relative to the government

$$\delta_{xz} = \begin{cases} 1, & f(x6,x18,x19,x20,x21,x22,x23) \geq k_{xz}(t) \\ 0, & \text{else} \end{cases}$$

action function of government's action relative to the LSC

$$\delta_{zx} = \begin{cases} 1, & f(z12,z13,z14) \geq k_{zx}(t) \\ 0, & \text{else} \end{cases}$$

3.3.3 Action made by the Government relative to the society, and vice versa, in *cooperate* condition

Government to Society	Society to Government
z15. Educate public on environmental and health dimensions of mining z16. Engage with mining corporation, NGO and society in handling environmental problems caused by mining activities z17. Improve Environmental Issues Action quality and linkage with permitting decisions z18. Collect data set of environmental degradation caused by mining, including baseline conditions	y12. Adhere the regulation issued by the government y13. Keep the conservation land well y14. Actively joint the government program on environmental issues

For *defect* condition, actions taken by the agent are negation of the actions mentioned above.
From those conditions, we can make *action function* of the interaction between those two agents in the following:

action function of government's action relative to the society

$$\delta_{zy} = \begin{cases} 1, & f(z15,z16,z17,z18) \geq k_{zy}(t) \\ 0, & \text{else} \end{cases}$$

action function of society's action relative to the government

$$\delta_{yz} = \begin{cases} 1, & f(y12,y13,y14) \geq k_{yz}(t) \\ 0, & \text{else} \end{cases}$$

3.4 Socio-Cultural Sector

Due to the place of mining resources that usually lie in the remote area, so the mining site in Indonesia is usually built there as well. This condition makes several socio-cultural consequences. The mining societies always have their own culture, and in many cases the culture brought by them collide with the indigenous people's culture. And usually, due to the imbalance treatment by the government, and also the strength of mining society, indigenous people often become marginalized from their home town. Concerning this condition, we need a more fair honour and treatment to the indigenous people, so they can survive culturally.

3.4.1. Action made by Mining Corporation relative to the society (people surrounding the mining site), and vice versa, in *cooperate* condition

Mining Corporation to Society	Society to Mining Corporation
x24. Make the local people as part of mining industry, with e.g. build a mining city as part of the prior city x25. Sponsor conservation movement of indigenous culture of local people x26. Adapt the indigenous culture in mining site living	y15. Making the culture adaptation brought by mining industry with its people

For *defect* condition, actions taken by the agent are negation of the actions mentioned above.
From those conditions, we can make *action function* of the interaction between those two agents in the following:

action function of Mining Corporation's action relative to the society (people)

$$\delta_{xy} = \begin{cases} 1, & f(x24,x25,x26) \geq k_{xy}(t) \\ 0, & \text{else} \end{cases}$$

action function of Society's action relative to the LSC

$$\delta_{yx} = \begin{cases} 1, & f(y15) \geq k_{yx}(t) \\ 0, & \text{else} \end{cases}$$

3.4.2 Action made by LSC relative to the Government, and vice versa, in *cooperate* condition

Mining Corporation to Government	**Government to Mining Corporation**
X27. Sponsor conservation movement of indigenous culture of local people	Z19. Accomodating development non-mining infrastructure of facilities in the mining town.

For *defect* condition, actions taken by the agent are negation of the actions mentioned above.
From those conditions, we can make *action function* of the interaction between those two agents in the following:

action function of LSC's action relative to the government

$$\delta_{xz} = \begin{cases} 1, & f(x27) \geq k_{xz}(t) \\ 0, & \text{else} \end{cases}$$

action function of government's action relative to the LSC

$$\delta_{zx} = \begin{cases} 1, & f(z19) \geq k_{zx}(t) \\ 0, & \text{else} \end{cases}$$

3.4.3 Action made by the Government relative to the society, and vice versa, in *cooperate* condition

Government to Society	**Society to Government**
z.20 Make indigenous culture conservation program	Y16.Preserving indigenous cultural objects actively.

For *defect* condition, actions taken by the agent are negation of the actions mentioned above.
From those conditions, we can make *action function* of the interaction between those two agents in the following:

action function of government's action relative to the society

$$\delta_{zy} = \begin{cases} 1, & f(z20) \geq k_{zy}(t) \\ 0, & \text{else} \end{cases}$$

action function of society's action relative to the government

$$\delta_{yz} = \begin{cases} 1, & f(y16) \geq k_{yz}(t) \\ 0, & \text{else} \end{cases}$$

While the four modules completed, it is possible to have the integral module and system analysis by pursuing the intersection of the variables regarding to the effects of the intersections.

4. Simulation Result

The simulation modeling the sociological aspects in Indonesian mining site in this paper apparently classified into two parts. The first part is the model uses the 3IPD and the other part use the IPD.

4.1. Simulation result using the 3IPD

In this part we use model of simulation regarding the Akiyama and Kaneko's model payoff matrices. In figure 3 we can see the example of the game play between the three agents that reflected the pay off function that used in this simulation. The program made in three modules, while every module consists of round of 3IPD tournament. The arithmetically solution will be find after the three round on every case of module gives data and multiplexed such quantification above in section 3.

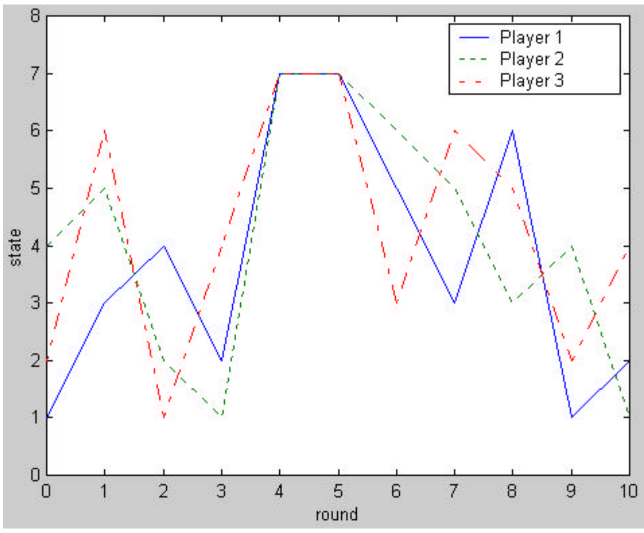

Figure 3

Example of tournament of the three iterated player prisoner dilemma that used in this paper showing the payoff matrix. The horizontal axis shows rounds, while the vertical axis shows the states of the players. Dotted lines are drawn near states 2 and 5. Players whose state is between the dotted lines can get scores. In that tournament examples, we can easily see that all players will gain same score 18.

The simulation on every module shows that three players must split into two and one to gain score or point. As a result of simulation, we will find that at least there are two kind of differentiation may be appeared.

- **Class Differentiation:** A biased differentiation. The role are fixed by players and a particular player loses on the average and is exploited by others. In this case, it is obvious how an agent can be exploited hard by the coalitions of the other two agents so forth, that every change (mutation) in the coalitions will remain the poor agent to be exploited (no point to be gained). Moderately, in mining site society, we can say that it is possible regional government and mining corporation build coalitions unfairly that sustain their own gain while exploiting the society in the mining site as simulated in figure 4.
- **Temporal Differentiation**: the roles of players to form coalitions change with time. This is probably the culmination of evolutionary social system in mining site that the score gain of each agents: regional government, mining corporation, and the society surrounding the mining site can not be gain simultaneously in one round, but in three sequential rounds. While this condition happens, the three agents are said to build good and optimum coalitions that sustain the whole social system that settle in the mining site. In other words, the three agents will have their own round about the time it gains score or economically gain on the system.

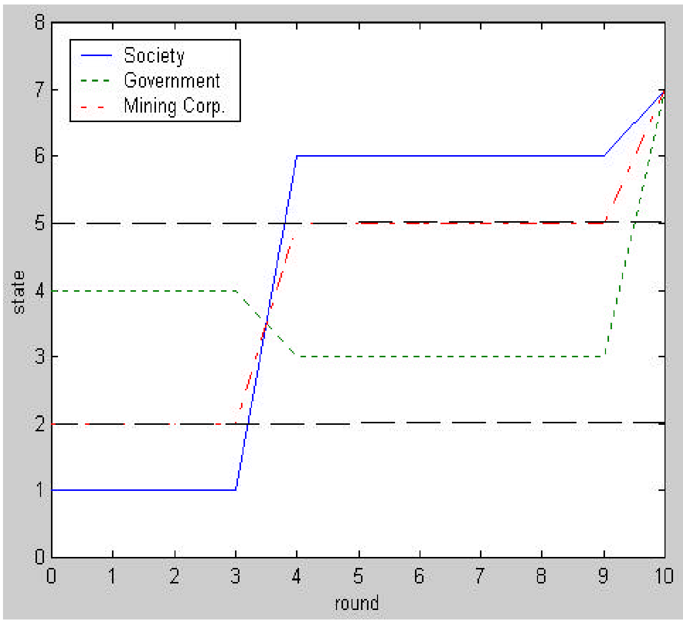

Figure 4

A class differentiation that showed coalitions of regional government and mining corporation will exploit unfairly the society, makes the system become not sustain that shall be mutated in order to gain conditions while the three agents can sustain well. From the picture we can see that the society never get point or score while the other three agents gain the maximum benefit on the exploitation. This is a model on economic module

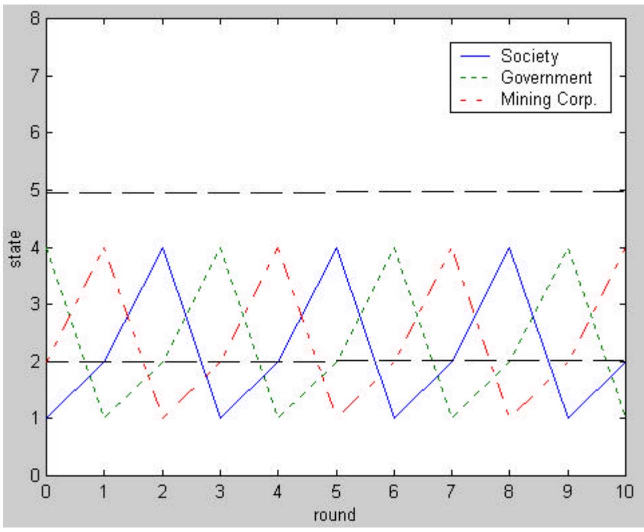

Figure 5

The type of temporal differentiation. This is an ideal model and the self-organized society will be evolved to the condition in the temporal differentiation. In this module we can see that the three agents gain scores sequentially that every agents will sustain the system. This is a computational proof that each agent will never gain score simultaneously but must be set to be temporal differentiation as suggested above.

In every module: economically each agent must set their strategy into the temporal differentiation therefore the whole sociological aspects will sustain well. In figure 6 we can see clearly how agents mutate such conditions that the system turns out to be the in temporary differentiation with the memory length about 4 (maximum). As a matter of fact, the social system gains its equilibrium in temporary differentiation while each agents gain the score sequentially in each module.

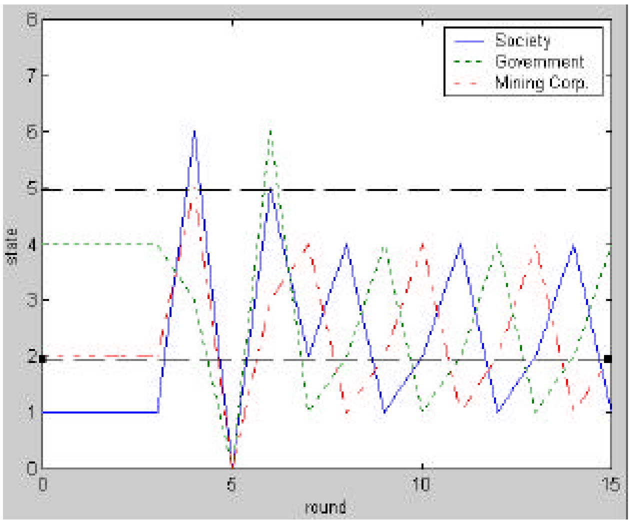

Figure 6

The agents mutate such a condition that the system turns out to be in temporary differentiation. In the beginning the system starts as class differentiation, there exists a mutual coalition among the mining corporation with the regional government that excludes the society surrounding the mining-site. The mutation in period 6 (with memory length 4) get the system to be temporary differentiation. In this module the condition become stable and each agent gains score sequentially.

4.2. Simulation Result Using the IPD

Using the IPD to simulate the interactions among agents in Indonesian mining site, we use IPD with three strategies in each tournament. The three strategies represents the agents: society, mining corporation, and the regional government. Each of the strategies given population three, and the three population will meet simultaneously in every round. We can find obviously that this part of simulation will be very different with the simulation before while using the 3IPD, since in this part the agents set to be very independent and cannot be assumed building coalition.

In figure 7, we can see an example of interaction, while the mining corporation represented by the tit-for-tat strategy, the society represented by the random strategy, and the society represented the all-defect strategy. We see that in the 4^{th} generation, the society has been excluded from the interactions, that reflected the conditions that the society and the activists has no other influence to the social system. Moreover, the regional government shows also their impotence while the regional government also excluded in 6^{th} rounds. In this simulation we can see that the winner of the tournament is the mining corporation, while they gain the whole population to influence the whole society. As a matter of fact, this condition shows that the best strategy to gain the sociological influence to the whole society in mining corporation is to represent the tit-for-tat strategy, while the sociological reflection can be seen in tables in part 3 of the paper. Once playing cooperate, and do the next action using the last opponent's action whether defect or cooperate.

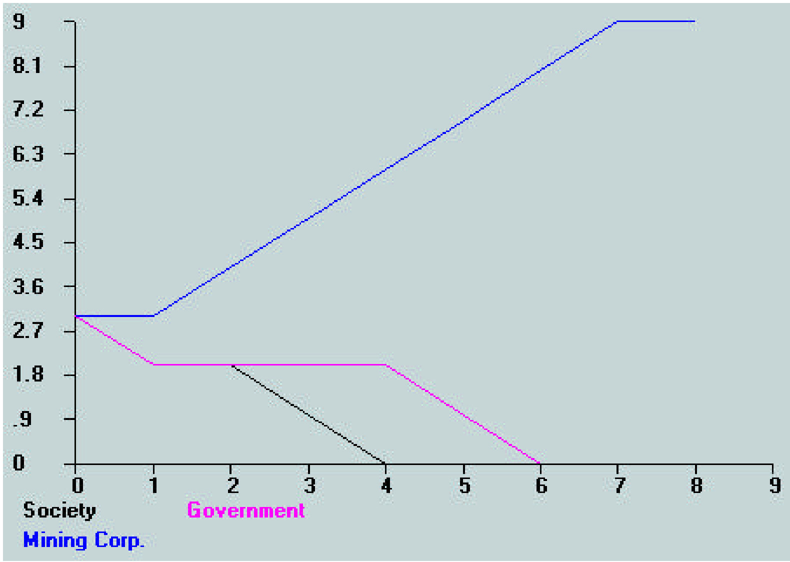

Figure 7

The condition of the co-evolution while the mining corporation using the tit-for-tat strategy, the government using the random strategy, and the society all defect. By considering the tables in part 3 of the paper, we will see how this strategies will be implemented as when to defect whether to cooperate.

In economical aspects, while the mining corporation well serve the society and the government therefore can be said to be cooperate, the society always defect to the government policies and the mining corporation, and the government defect to the society and also to the mining corporation while the whole bureaucracy seems to be full of corruption, we can see the result of simulation to be the winning of the corrupt bureaucracy. This conditions are simulated by setting the two first strategy of mining corporation are cooperate, the government defect, and the society cooperate, while the remain of each is random. From here we can see that the government gains the best pay-off but the mining corporation and the society will always be excluded. The mining corporation will be no longer good at the exploitation (excluded in the 2nd round) while the society described to be in constant.

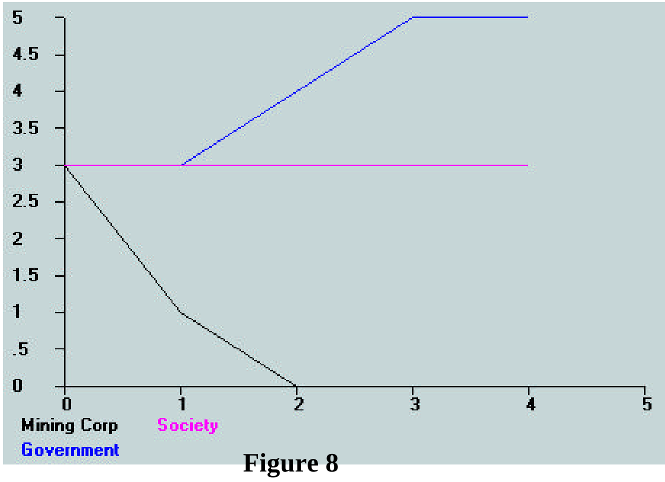

Figure 8

Economically, the Government represented by the Defect-Defect-Random strategy, the society Defect-Random, and the Mining Corporation Corporate-Corporate-Random strategy. In this case, the government gains the maximum payoff, but the mining corporation cannot longer to exploit the natural resources, in other words that the mining corporation will never be sustainable sociologically. By this simulation we can see that the defection will gain payoff better than cooperation while one or more other agent cooperate.

5. Limitation of the Simulation and Further Possible Improvement

The simulation built is made in purpose of showing the co-evolution of agents, in this case: mining corporations, regional government, and society surrounding the mining-site in separated same-simulated modules: political, economical, and environmental aspects. Thus, the separation of the modules as an impact on the lack of survey in the mining-field give separated (same-simulated) analysis also. Apparently, if the three modules can be integrated onto one big simulation that can integrate the same parameters of the three modules, σ, while σ is the same possible variable in the payoff functions of the interacting agents (σ=a,b,c... where δ_{ij} = 1, if $f(a,b,c,d,...,t) \geq k(t)$, $\sigma \in \mathbf{R}^n$).

The integrated simulation will be approach computationally by the multi-level programming in genetic algorithm (Gen:1997), that in the output we will gain the optimum value and the best possible alternative suggesting strategies can be followed in order to get the sustaining social system – the agents act cooperatively to gain scores sequentially. In either case, the analysis of this simulation result will depend on the very tight qualitative parameterization that requires the field tight qualitative sociological approach also. A good integrative simulations that reflect the real conditions that face in the reality shall need the primary data gained by the field survey of pre-defined mining site as a case of study.

5. Conclusion

The study of the social system in Indonesian mining site needs a unique approach as the social system there cannot be categorized easily as urban or even rural society. Perspectives that society can be seen as self-organized system can be a good approach to preserve alternative solutions of the scientific challenge. As the main collective actions in the society of mining-site often defined as three independent agents (certainly with some degree of independence) we can categorize there are three agents play the main role of the society: regional government, mining corporation, and the society with any backgrounds (origin or the newcomers).

The usage of IPD in analysis of social evolution has given an important role to approach the complex dynamic system as a self-organized system. It is obvious that in the mining site sociology we can model the three main role-players as 3IPD while the three of it tends to be non-cooperative. The simulation using this idea can bring to the optimization of the strategy that can be taken by those agents since holistic sustainability is very important to the whole system.

By the simulation we can see that the two coalition exclude and (unfairly) exploited the other one, that seemingly will disturb the sustainability of the whole system. By using the simulation we can see how this happen in class differentiation. Nevertheless, we can see that the optimum condition is in the temporary differentiation, while each agent gain scores temporarily and sequentially in order to gain the whole system keep sustainable. This can be seen in the simulation of each module reserved: politically, economically, environmentally, and culturally.

The question is how the whole module can be integrated that we can get holistic analysis and alternative suggestion on playing the strategy. This can be done by pursuing the same variables in payoff functions of interacting agents on each module that become the input to the further programming and analysis. This will be much more depending on the primary data collecting shall be done for the further approach.

Acknowledgement:
The authors realize that the simulation will be much better reflecting the factual and real condition while it was made with the primary data that shall be collected in sociological survey in some mining sites as case of study. Sponsors or donations onto the complete simulations are expected. The authors thanked some colleagues in the West Student Center Institut Teknologi Bandung with the cooperation and the lend PC that used to simulate the computer program.

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