A Co-operative Environmental Management Between China & Algeria

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Abstract
Environmental studies involve every issue that affects living organisms; therefore, positive and realistic planning is needed to balance between biology, geology, chemistry, physics, engineering, sociology, health and economics. And this is the mission of environmental management. Recently, sustainable development is widely adopted and industry created new myths about environmental management. The critical myth was the assumption that industry was a little sloppy in the past, while being assured that it can be superior and doing better in the future with favorable environmental management and technology. The most serious environmental problems facing our planet require cooperative solutions. Moreover, game theoretic thinking allows environmental movements to effectively identify the suboptimal and truly optimal scenarios of environmental management policy in order to preserve biodiversity, build new ecosystems, and keep existing ones intact. Thus, this research depended on game theory to propose a co-operative environmental management between China and Algeria. For that, firstly, this study analyzed the case where there is no co-operative game between China and Algeria to see whether they benefit or not, then it proposed a co-operative game to benefit both countries. Consequently, it found that China and Algeria can get benefits through co-operating in waste minimization by using some technological incentives.

Keywords
Environmental Management, Game Theory, Policy, Co-operative Solutions, China, Algeria

I. Introduction

In the recent past, we have been reluctant to see either local or global environmental management as an integral part of our daily affairs (Meg et al, 2005). Environmental studies involve every issue that affects living organisms. Various interacting components of environment are biology, geology, chemistry, physics, engineering, sociology, health and economics. Positive and realistic planning is needed to balance them. Therefore, environmental science is essentially a multidisciplinary approach. The mission of environmental management is to identify the needs and constraints of studies determined systems (factory councils, economic entities ...), to look for new solutions for the daily management of their environment, in the broadest sense.
An integrated treatment of environment and resources has become more pressing since the notion of sustainable development was widely adopted during the 1990s (Jeroen, 2007). And during that period, industry created new myths about environmental waste in order to change its image. The critical myth was the assumption that we can cleanup our environment. In other word, we can admit that industry was a little sloppy in the past, while being assured that we can do better in the future. With favorable environmental management and technology, we can stop releasing pollutants into the environment. This strategy is often dubbed "end-of-pipe" cleanup (Linda & John, 2010). Efficient and effective management of the environment can sustain the provision of vital ecosystem services such as climate stabilization, clean drinking water supply, recreation opportunities and amenity...(Turner & Daily, 2008).
Environmental policy theory assumes perfectly rational agents and assigns a central role to efficiency of policy instruments. The importance of environmental policies is to regulate the behavior of humans and economic organizations by setting a clear overall goal such as "zero emissions" (Jeroen, 2007). Not too long ago, many companies had chosen between operating their businesses either environmentally responsible or economically effective. Therefore, environmental protection is a long-term issue of survival for individuals, companies, and societies. And environmental concern must be the cornerstone to our operations (Eberhard and Hans, 2002). By stimulating innovation, strict environmental regulations can actually enhance competitiveness (Porter and Linde, 1995). According to DeCanio (1993), in the metaphor economists often cite, 10 USD bills will never be found on the ground because someone would have already picked them up. In this view, if complying with environmental regulation can be profitable, in the sense that a company can more than offset the cost of compliance.
The most serious environmental problems facing our planet require cooperative solutions such as ensuring the sustainability of the Murray-Darling river system requires the cooperation of several states, preserving species (migratory birds) with ranges spanning several countries typically requires the cooperation of all countries involved, and reducing the effects of anthropogenic climate change requires the cooperation of all greenhouse gas emitting nations. Colyvan made the case for game theory as a potential antidote to the environmental pathologies facing the world. And he stated that game theory should be a major tool in implementing effective environmental management and policy (Colyvan et al, 2011). In summary, game theoretic thinking allows environmental movements to effectively identify the suboptimal and truly optimal scenarios of environmental management policy in order to preserve biodiversity, build new ecosystems, and keep existing ones intact.
Therefore in this context, this research will depend on game theory to propose a co-operative environmental management between the two different countries China and Algeria.

II. Literature Review

Game theory was originally developed during the cold war to model the nuclear arms race and first strike strategies. Since then, the theory has become indispensable in economics and is enjoying applications in diverse areas such as ethics, biology, dating, and more recently, in environmental management and policy (Colyvan et al, 2011). Game theory was preoccupied with two sum interactions. And the earliest record of such use was the 1881 work of Francis Edgeworth which was discovered in 1956 by Martin Shubik (Anthony, 2003). The earliest example of a formal game-theoretic analysis was the study of a duopoly by Antoine Cournot in 1838 (Theodore & Bernhard, 2001). Game theory in the modern era was ushered in with the publication in 1913, by the German mathematician Ernst Zermelo (Anthony, 2003). The

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mathematician Emile Borel suggested a formal theory of games in 1921, which was furthered by the mathematician John von Neumann in 1928 in a "theory of parlor games" (Theodore & Bernhard, 2001, Anthony, 2003).

Game theory was established as a field in its own right after the 1944 publication of the monumental volume Theory of Games and Economic Behavior by von Neumann and the economist Oskar Morgenstern. In 1950, John Nash demonstrated that finite games have always had an equilibrium point, at which all players choose actions which are best for them given their opponents' choices. This central concept of non-cooperative game theory has been a focal point of analysis since then. In the 1950s and 1960s, game theory was broadened theoretically and applied to problems of war and politics. Since the 1970s, it has driven a revolution in economic theory. Additionally, it has found applications in sociology and psychology, and established links with evolution and biology. Game theory received special attention in 1994 with the awarding of the Nobel Prize in economics to Nash, John Harsanyi, and Reinhard Selten. At the end of the 1990s, a high-profile application of game theory has been the design of auctions. Prominent game theorists have been involved in the design of auctions for allocating rights to the use of bands of the electromagnetic spectrum to the mobile telecommunications industry. Most of these auctions were designed with the goal of allocating these resources more efficiently than traditional governmental practices, and additionally raised billions of dollars in the United States and Europe" (Theodore & Bernhard, 2001). In 1997, Roger analyzed in his book the conflict using Game Theory.

During the recent century there are several studies about game theory and environmental management such as: in 2001, Michael & Bianca made working paper on endogenous coalition formation in global pollution control. Later in 2003, Ignazio depended on game theory to make an introduction to the economy of the environment. Moreover, in 2005, Carlo, Johan and Michael used game theory for making working paper about optimal transfers and participation decision in international environmental agreements.

III. Background on Game Theory

Game theory is the formal study of conflict and cooperation. Game theoretic concepts apply whenever the actions of several agents are interdependent. These agents may be individuals, groups, firms, or any combination of these. The concepts of game theory provide a language to formulate, structure, analyze, and understand strategic scenarios" (Theodore & Bernhard, 2001).

According to Anthony (2003), game theory is the theory of independent and interdependent decision making. It is concerned with decision making in organizations where the outcome depends on the decisions of two or more autonomous players, one of which maybe nature itself, and where no single decision maker has full control over the outcomes. A game theory model is constructed around the strategic choices available to players, where the preferred outcomes are clearly defined and known.

Therefore, game theory arose from the analysis of competitive scenarios, the problems are called "games" and the participants are called "players". In short, game theory deals with any problem in which each player's strategy depends on what the other players do.

There are two fundamental types of games: Sequential and simultaneous. In sequential games, the players must alternate moves; in simultaneous games, the players can act at the same time. These types are distinguished because they require different analytical approaches

A. Sequential Games

A sequential game is one in which the players take alternate turns to make their choices (Barry, 2011). To analyze a sequential game, first construct a game tree mapping out all of the possibilities (Luís, 2000). Then follow the basic strategic rule: "look ahead and reason back:"

1. Look ahead to the very last decision, and assume that if it comes to that point, the deciding player will choose his/her optimal outcome (the highest payoff, or otherwise most desirable result).
2. Back up to the second-to-last decision, and assume the next player would choose his/her best outcome, treating the following decision as fixed (because we have already decided what that player will pick if it should come to that).
3. Continue reasoning back in this way until all decisions have been fixed.

If you actually play out the game after conducting your analysis, you simply make the choices you identified at each of your decisions. The only time you even have to think is if another player makes a "mistake." Then you must look ahead and reason back again, to see if your optimal strategy has changed. It is important to know who is going to move first in a sequential game as there may be a first mover advantage, or even a first mover disadvantage (Barry, 2011).

B. Simultaneous Games

Turning to simultaneous games, it is immediately apparent that they must be handled differently, because there is not necessarily any last move. A simultaneous game is one in which the players effectively make their decisions at the same time. They don't actually have to make their decisions at exactly the same time as long as each player doesn't know the other player's choice when they choose their own strategy (Barry, 2011). The groundwork for developing strategies for simultaneous games:

- If you have a dominant strategy, use it.
- Otherwise, look for any dominated strategies and eliminate them.

In addition, Anthony (2003) divided games into three categories of games: games of skill, games of chance, and games of strategy.

C. Games of Skill

Games of skill are one player games whose defining property is the existence of a single player who has complete control over all the outcomes.

D. Games of Chance

Games of chance are one player games against nature. The player doesn't control the outcomes completely and strategic selections do not lead inexorably to certain outcomes. The outcomes of a game of chance depend partly on the player's choices and partly on nature, who is second player.

D. Games of Strategy

Games of strategy are games involving two or more players, not including nature, each of whom has partial control over the outcomes. Games of strategy are games involving uncertainty. They can be sub-divided into two player games and multi player games.

IV. Research Methodology

In order to analyze a co-operative environmental management, this study uses game theory as a tool for the management of environmental problems, and it suggests a co-operation between China and Algeria against environmental pollution through applying co-operative game theory approach between these two countries. And based on some general forms of the previous researche of Roger Ignazio (2003), this study, firstly, analyzes the case where there is no co-operative game between China and Algeria to see whether they benefit or not, then it proposes a co-operative game to benefit both countries.

V. Research Discussion

It is well known in the economic literatures that a long term cooperative relationship can be sustained as equilibrium in a variety of economic situations without any legal enforcement. Fudenberg & Maskin (1986) showed that a long term cooperative relationship is possible by an informal enforcement mechanism if the same players play the same substrate game repeatedly. They said that if players have frequent and long term relationships, then the threat of future retaliation by the single opponent of a deviator can be strong enough to enforce cooperation.

A. Non Co-operative Game Between China & Algeria

In this case, we analyze the non co-operative game between China and Algeria under the following assumptions:

1. We have two players, player one is the country China and player two is the country Algeria;
2. Each player has a finite, very limited set of strategies;
3. Players choose their strategy simultaneously;
4. Games are single shot games.

According to these assumptions, this study applies the prisoner's dilemma game where the two players (China & Algeria) refuse to co-operate. So reaching a solution worse than that they could reach by co-operating, but they have no incentive to act co-operatively. It proposes that each country can co-operate at the project of waste minimization or not co-operate at the project of waste minimization. And according to the general form of prisoner's dilemma (Ignazio, 2003) shown in table "1", this study proposes that each country awards a benefit $B = 3$ to the project of waste minimization, and the cost of the project is equal to $C = 4$ for both countries China & Algeria. The joined benefit is equal to $2B = 6$ and it is greater than the cost of the project whose implementation is therefore socially efficient.

Table 1: The General Form of Prisoner's Dilemma

A vs. B	c	nc
c	$B - \frac{C}{2}, B - \frac{C}{2}$	B-C, B
nc	B, B-C	0,0

Source: Ignazio, 2003

A vs. B (country A vs. country B);
c (co-operate at the project "strategy c"), nc (not co-operate at the project "strategy nc");

$$B < C; B > \frac{C}{2}.$$

If each country implements the project by itself it incurs in loss equal to $B – C = 3 - 4 = -1$, if both implement the project they get a gain equal to $B - \frac{C}{2} = 3 - \frac{4}{2} = 1$ whereas if the project is abandoned they both have neither a gain nor a loss. And the table "2" shows the prisoner's dilemma for China & Algeria.

Table 2: Prisoner's Dilemma of China & Algeria

China vs. Algeria	Waste Minimization	Not Waste Minimization
Waste Minimization	1 , 1	-1 , 3
Not Waste Minimization	3, -1	0 , 0

From these structures we see that the only "Nash Equilibrium" is the strategy profile (nc, nc) not co-operate in the project of waste minimization whose payoffs are (0, 0), and this is lower than those that could be attained if the two countries China and Algeria would co-operate in waste minimization (1, 1).

B. The Co-operative Game between China & Algeria

In this case, the assumption is that there is a co-operative game between China and Algeria, and based to Ignazio (2003) this game is based on two stages:
At the first stage it has a coalition game during which countries decide to adhere or not the coalition.
At the second stage it has a pollution game where the countries of coalition act as single player against the other that act selfishly as singletons.
We suppose to have the two countries China and Algeria with a quantity ei to the global pollution. The total pollution amounts to:

$$X = \sum_i e_i \qquad (1)$$

Such pollution causes damages both in China and Algeria. We propose that the self induced damage has the following expression:

$$m_i X = m_i \sum_j e_j \qquad (2)$$

Where $m_i \geq 0$ represents the marginal damage for country i: m_i

$$= \frac{d}{de_i} m_i \sum_j e_j \qquad (3)$$

We have: A global marginal damage $M = \sum_i m_i$ (4)

A total ordering on the marginal damages, since we can always reorder the countries so to get:

$$m_1 \geq m_2 \qquad (5)$$

The main problem is that each country gets a benefit $B(e_i)$ from its contribution e_i, as to the country i we have, therefore:

$$W_i (e_i, e_{-i}) = B(e_i) - m_i X \qquad (6)$$

To get such solution for environmental pollution the countries should work to reach the co-operative solution that maximizes:

$$\sum_i W_i (e_i, e_{-i}) = \sum_i (B(e_i) - m_i X) \qquad (7)$$

Considering the expression for X, it is easy to see that the first order condition applied to relation (7) gives the following result:

$$B'(e_i^*) = \sum_j m_j = M \qquad (8)$$

So that the value of admissible emissions ei* for country i at the social optimum is such that the marginal benefit $B'(e_i^*)$ for

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country i is equal to the global marginal environmental damage M. So if both of China and Algeria act co-operatively they consider the global value $M = m_1 + m_2$ so that their emission levels drop to lower values e_1^* and e_2^*. In this case as the global pollution we have:

$$X^* = e_1^* + e_2^* < X^0 = e_1^0 + e_2^0 \qquad (9)$$

Therefore the global pollution in the co-operative case X^* is lower than that in the non co-operative case X^0. And their emission levels drop from e_1^0, e_2^0 to e_1^*, e_2^*, and this is shown clearly in the following fig. "1". (Where B'_1 is marginal benefit for China, m_1 is marginal environmental damage for China; e_1 is the emission level of China, B'_2 is marginal benefit for Algeria, m_2 is marginal environmental damage for Algeria and e_2 is the emission level of Algeria).

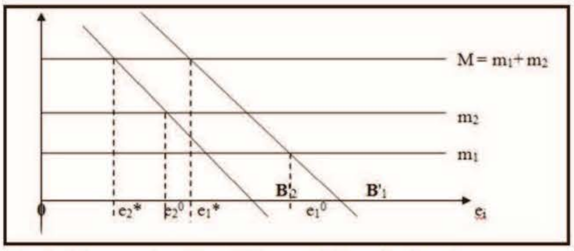

Fig. 1: Co-operative Case Between China & Algeria

China is technologically advanced country than Algeria, and in this case it is easy for China to engage in waste minimization plan, whereas Algeria may find it hard to face the costs of the waste minimization plan, owing to the lack of proper technology and the high costs. Therefore, there are differences between marginal benefit B'_1 & B'_2, and between marginal damage m1 & m2. In this case we can create some incentives to engage in co-operation with Algeria and China through transferring the technology from China to Algeria.

We suppose that SA is the strategic of China, SB is the strategic of Algeria.

$S_A = \{c, nc\}$, $S_B = \{c, nc\}$

If we have the payoffs of the table "3" (based on Ignazio, 2003) with the following orderings: $a_1 > b_1 > c_1 > d_1$,

$a_2 > b_2 > c_2 > d_2$,

$b_1 + c_2 > c_1 + b_2$

Table 3: General form of Co-operation

A vs. B	c	nc
c	b_1, c_2	d_1, a_2
nc	a_1, d_2	c_1, b_2

Source: Ignazio, 2003

If we suppose that for China: $a_1 = 8$, $b_1 = 7$, $c_1 = 2$, $d_1 = 1$, and for Algeria: $a_2 = 7$, $b_2 = 5$, $c_2 = 3$, $d_2 = 2$, then we can get the table "4" as following:

Table 4: Co-operation between China and Algeria

China vs. Algeria	Waste minimization	Not waste minimization
Waste minimization	7 , 3	1 , 7
Not waste minimization	8 , 2	2 , 5

So that (nc, nc) "not waste minimization" is the only Nash Equilibrium of the game. If China and Algeria would decide to switch to the co-operating solution (c, c) "waste minimization", the country Algeria will imply a loss equal to $b_2 - c_2 = 5 - 3 = 2$, whereas China can get a net benefit equal to $b_1 - c_1 = 7 - 2 = 5$. Therefore if China transfers technology to Algeria, the incentive (i: incentive of technology's transfer), where $i > 0$, so that the following conditions are satisfied:

For China we have: $b_1 - i > c_1$, and for Algeria we have: $c_2 + i > b_2$, then according to the table "5" we can get the table "6".

Table 5: General form of Co-operation With Incentives

A vs. B	c	nc
c	$b_1 - i$, $c_2 + i$	d_1, a_2
nc	a_1, d_2	c_1, b_2

According to the previous conditions we have:

$i = 3$,

$b_1 - i = 7 - 3 = 4 > c_1$

$c_2 + i = 3 + 3 = 6 > b_2$

So the benefits of China and Algeria from the co-operation using incentives are shown in the following Table "6".

Table 6: Co-operation Between China & Algeria Using Incentives.

China vs. Algeria	Waste minimization	Not waste minimization
Waste minimization	4 , 6	1 , 7
Not waste minimization	8 , 2	2 , 5

Therefore, this game also has the Nash Equilibrium at (nc, nc), however, if both of China and Algeria decide to switch to the co-operating solution with incentives (c, c), then:

Algeria can get a benefit equal to

$(c_2 + i) - b_2 = (3 + 3) - 5 = 1$.

And China can get a benefit equal to

$(b_1 - i) - c_1 = (7 - 3) - 2 = 2$.

VI. Conclusion

Efficient and effective management of the environment can conclude sustainable development and this later can be achieved by ensuring co-operation in environmental management. However, cooperative relationship can be sustained as equilibrium in a variety of economic situations without any legal enforcement. Subsequently, China and Algeria can get benefits through co-operating in waste minimization by using some technological incentives. However, it requires that both countries respect the rules of this co-operation. Because if the beneficiary country does not fulfill the associated obligations there is no effective way, for the donor country, to get benefits of the transferred technology, so it may result a drawbacks of agreements.

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