Economic behavior to the environmental equilibrium: analysis from game theory

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Abstract

This research aims to show how models from neoclassical economics theory points on environmental problematic. since environmental crisis reflects directly on the operation of the economics, socials, and ecological systems. By using the game theory methodology, we proposed a concrete analysis about the individual economic behavior within the environmental action as a part of their utility function. We observe that once the relations between society and nature, among two (or more) agents in relation to a natural element become conflicts of interest, this ceases to be an economic problem to become an ethical problem. Therefore, it can clearly be argued that it is not a failure in economic theory, since it even generates possible solutions from a well-established institutional framework, answering what different authors have questioned regarding neoclassical theory as responsible for a problem that is out of it. In conclusion, we consider that envi-ronmental crisis it is not a neoclassical theory problem but an ethic problem, and it requireseffective incentives to achieve strong sustainability.

Keywords : Economic behavior, game theory, ethical problem, moral philosophy

Introduction

The environmental crisis that societies are currently experiencing, it has been pointed out that economic science (under the guidelines of the neoclassical theory paradigm) and particularly the capitalist economic system is primarily responsible for said crisis (Martínez, 2004; Fazio, 2012), which includes the overexploitation of natural resources for commercial purposes, unequal distribution of resources, excessive urban growth, pollution among others (Delgado, Espina, & Sejenovich, 2013).

On these statements arise relevant questions from the philosophy of science such as the following: economic science, as a scientific discipline, is in crisis?; Is the neoclassical economy responsible for environmental anomalies ?; Are there sufficient anomalies to refute the neoclassical paradigm ?; Can the dominant (neoclassical) paradigm solve the anomalies attributed to it?, It is necessary to solve these types of questions before arguing that a scientific theory, in this case the neoclassical economic theory, is obsolete given its inability to solve problems. The objective in this paper is precisely to analyze the application of neoclassical theory from the behavior of the economic agent against a situation of environmentally friendly behavior, through the methodology of game theory; in order to indicate if the theory is effectively incapable of solving the type of economic phenomena that are currently affecting societies, or if these problems are generated by other circumstances that escape the actions of the neoclassical theory.

Economic behavior and application of economic science

It is called economic behavior, any behavior directed by economic laws (García de la Sienra A., 1998) This dynamic is under the concept of maximization of preferences, where, each individual seeks to improve their utility (or welfare) from the decision making offered by the conceptual framework of the economy. Economic problems, then, become decision problems, which are seen from the perspective of game theory:

An individual decision problem is a game in which one of the players is the individual and the other is nature. The "pure strategies" of nature are called states of nature, and these are represented from the neoclassical theory by the market. Since the market has no preferences, only the utility of pure strategy profiles for the personal player is considered: where *uij = u (s_i, sj)* is the utility for the individual, resulting from the state of nature being s_j and the choice of agent is s_i. The pair (s_i, s_j) represents the result that occurs if the prevailing state of nature is sj and the agent chooses the action s_i (García de la Sienra A., Theory of choice).

When the individual (decision maker) is forced to choose an action from a set of possible (known) courses of action, the decision problem is composed of the following elements: The objectives of the decision maker; the states of nature he faces; feasible courses of action, also called actions, choices or decisions; the consequences or results that come from the conjunction of each action with each state of nature; and the degree of uncertainty of the consequences of each possible action (García de la Sienra A., Theory of choice) The central stage of the research is the market, which is given from the institutional point of view by individuals, who participate either as consumers or producers; The explanation of their behavior is based on the assumption that individuals try to maximize their own satisfactions by behaving rationally (Dopfer K., 1978).

> The economic problem that the individual typically faces is to make a better choice between several given alternatives. The basic conditions under which individual maximization operates are exogenously determined and do not change in the model; production and utility functions are stable, and the same applies to the distribution of income and wealth (Dopfer K., 1978, p. 16).

The problem of utility maximization is a set of personal agents that depend on their individual choice. However, the object on which the various branches of the economy deal, which address economic problems, are phenomena that occur at precise levels or levels of social formations (Barcelo, 1992). Which leads to the idea of forming a mechanism that leads to social welfare; Therefore, since its inception, economic theory has been considered as a source of recommendations for the elaboration of public policies (Beker, 2002).

The recommendations arising from the neoclassical theory are about the concept of balance. Hence, one of the models of application of the theory is through welfare economics; This application extends the estimates of individual utility to a welfare state for all members of the economy. When economists consider environmental issues, they point to the results of economic well-being. For this reason, an attempt is made to demonstrate an economic balance with respect to environmental conditions (which concern all human beings), so it is necessary to resort to such approaches.

2. Game theory and environmental decisions

With the objective of modeling an economic-environmental balance, this could only be achieved by resorting to the analysis of the decision-making of economic agents, which is adequately exposed from game theory.

The notion of environmental sustainability emphasizes the vital support of environmental systems, without which neither (economic) production nor humanity could exist. This life support includes the atmosphere, water and soil; All of these require being healthy so that the capacity of their environmental services is maintained. Therefore, environmental sustainability can be represented by a set of regulatory restrictions on the main activities that regulate the scale of the economic-human subsystem with respect to the physical-ecological system (Cafri & Schiliro, 2012).

Properly, game theory is a tool for the analysis of the interaction between rational agents, the formulation of hypotheses about their behavior and the prediction of the results of each interaction. From this point, it is very convenient for the analysis of environmental problems and for the application (enforcing) of environmental agreements that are based on cooperation (Cioni, 2006). In this framework, the possibility of two types of games is presented: cooperative and non-cooperative, given that economic anomalies with respect to environmental terms that generate market failures[1] are mainly presented in the form of external effects and as the problem of the free rider, this form is attached to the modeling of non-cooperative games, so that this tool is used for economic-environmental analysis.

Non-cooperative games

The fundamental law of game theory is that each player acts rationally, in the sense that he maximizes his expected utility by reacting to any profile of the other players; To explain it, the concepts of expected utility, strategies and balance are used.

Every non-zero finite sum of a non-cooperative game normally has at least a balance of n-tuple (orderly sequence) of pure or mixed strategies, which correspond to the decision to perform some action, taken with the sole in order to maximize the expected utility through a single shot in the game, that is, a single decision making. Once the dynamics of the theory are defined, Nash's theorem can be introduced: Every game strategically has a balance in mixed strategies

[1] Market failures are situations in which real circumstances deviate from the ideal and become inefficient outlets, so it is necessary to recommend corrective economic policies. Much of the content of the environmental economy is focused on identifying and correcting market failures in relation to the services that the environment provides to the economy.

(Nash, 1950). This balance is reached when all players have made use of their strategies and reached a level of utility in which no one can worsen or improve their situation.

The form of non-cooperative games allows describing interdependent strategies among n players, each being characterized by at least: a set of pure strategies Yes; and an expected utility function (Cioni, 2006).

$$u_i \rightarrow R$$

with

$$S = x_{i=1}^{n} S_i$$

Examples of non-cooperative games are given under the following simplified assumptions:

1. There are only two players;

2. Each player has a finite, real and limited set of strategies;

3. Players choose their strategies simultaneously;

4. Unless stated otherwise, the games are one-shot.

Thus, the most basic example of a non-cooperative game would be in the form of the prisoner's dilemma, which owes its name to the following scenario:

Given for two people, with strategies (S_1, S_2) one cooperative and one non-cooperative respectively. Two prisoners are assumed, who are in fact guilty of a felony, both are protected in separate cells. Contemplating their future, each of them perceives two strategies: (S_1), not admitting crime; and (S_2), confess everything. The prosecutor finds an opportunity to make them confess, implementing the following incentives: first, if neither prisoner confesses, the punishment will be 10 years in jail for both of them; second, with a single confession, and if only one prisoner shows evidence, then you have 8 years in jail for the cooperating prisoner and 20 years in jail for the non-cooperator; Finally, if both confess, then both receive a 15-year prison sentence (Ordeshook, 2003).

The result is that both prisoners choose the non-cooperative strategy among them (S_2), which is the most severe equilibrium sentence that both can receive equally; since they prefer not to cooperate with each other, so as not to risk having a greater punishment, because only one of them confesses and obtains the worst punishment.

P1/P2	**P2.(S1)**	**P2.(S2)**
P,1(S1)	(−10, −10)	(−20, −8)
P,1(S2)	(−8, −20)	(−15, −15)

Prisoner's dilemma for two people (Ordeshook, 2003).

Game features can be added as follows:

1. Each player has a dominant strategy;
2. If each person uses their dominant strategy, then the final exit will be a Pareto inferior optimum, in which both can find a better, unanimously preferable exit;
3. That their strategies are dominant means that even if players can communicate with each other beforehand and agree to avoid the lower Pareto outcome, if they cannot somehow make a binding agreement, then, each person will ultimately be affected by it. .

The operation of the game, where both prisoners have a dominant S_2 strategy. Regardless of what the other prisoner does, in which the performance is an exit that both prisoners prefer to achieve, it is the least favorable, it can be formally explained:
1. Each player can cooperate for a better exit of both (strategy c), or not cooperate (strategy nc);
2. Each player earns a $B = 3$ benefit by cooperating;
3. The cost to cooperate is equal in $C = 4$ for both players
The benefit enjoyed is equal in $(2)\ (B) = 6$ and is greater than the cost to cooperate, and therefore, its implementation is socially efficient. If each player decides to cooperate alone, that may incur an equal loss for $B\text{-}C = -1$. If both players cooperate, both reach an equal gain for $B\text{-}C\ /\ 2 = 1$ where if neither cooperates, then neither gets a profit or a loss (Cioni, 2006).
The result can be seen having the following preference structure:

1. $(nc, c) \succ A(nc, nc) \succ A(c, nc);$
2. $(c, nc) \succ B(nc, nc) \succ B(nc, c).$

From this structure it stands out that the only balance is the strategy offered in (nc, nc) where the payments are (0, 0), which is also less than where both can obtain a benefit if the two players cooperate (1, 1). By inspecting the prisoner's dilemma table, it is easy to see that if one player can implement the project by himself, the other can only benefit at no cost, incurring free-rider behavior. The same is always true if both players can agree to cooperate before starting the game (c, c); in this way both players would obtain a high common benefit. If, after signing a cooperative agreement, A is sure that B will comply with it, A will have strong incentives to divert his actions to (nc) and win 3 instead of just 1. The same holds for B. in this case, a free-rider behavior (to play (nc)) of one of the players can be provided as the best incentive for a non-cooperative movement identical to the other (Cioni, 2006).

A/B	**B(c)**	**B(nc)**
A(c)	$(B-C/2, B-C/2)$	$(B-C, B)$
A(nc)	$(B, B-C)$	$(0,0)$

Prisoner's dilemma general form (Cioni 2006)

In this situation, from the game of a single movement, there is no way for the two players to cooperate and reach the socially optimal solution (that is, the one offered (c, c)). The lack of incentives, or the uncertainty to a greater loss make the players prefer a lower Pareto exit, the same situation happens with the friendly behavior with the environment.

3. Non-cooperative environmental game with analysis of externalities and public goods

It is considered a reinterpretation of the prisoner's game that, as an example, an environmental game case is modeled on air pollution control in: (Ordeshook, 2003). From the affectation in the functions of utility of the individuals, according to the form of the externalities; where the strategies are now reinterpreted as (S_1) cooperative strategy: the payment of a fee that would be reflected in the regeneration of forests, where precisely the partiality of regenerated forest would be the public good Y[2]; and a non-cooperative strategy (S_2): not paying the fee. Two individuals A, B are assumed; with utility functions given with respect to the consumption of two goods X, Y, where the air available in the current pollution conditions would be good X (considering that, with a greater number of forests, one of the environmental services that it offers is the possibility of having cleaner air), which in turn is also a public good[3]

A/B	**B(S₁)**	**B(S₂)**
A(S_1)	$[U^A (X^A, Y^A, Y^B), U^B (X^B, Y^B, Y^A)]$	$[U^A (X^A, Y^A), (X^B, Y^A)]$
A(S_2)	$[U^A (X^A, Y^B), U^B (X^B, Y^B)]$	$[U^A(X^A,0), U^B(X^B,0)]$

Prisoner's dilemma: air pollution with consumer-consumer externalities.

The different outputs show that the fact of resorting to the non-cooperative strategy indirectly affects the utility of the other: the failure to pay their respective forest regeneration fee by one player reduces the total amount of forest Y that the other could consume, conditioning it to consume a necessarily smaller portion of Y than it could consume if both paid, only the portion regenerated for their own payment, considering that $Y^A + Y^B = Y^*$, and therefore, $Y^* > (Y^A)$, (Y^B). where the utility of the consumer is greater when it is a function of (Y^A, Y^B):

$$U^A (X^A, Y^A, Y^B) > U^A (X^A, Y^A) > U^A (X^A, 0)$$
$$U^B (X^B, Y^A, Y^B) > U^B (X^B, Y^B) > U^B (X^B, 0)$$

On the other hand, choosing the cooperative strategy clearly represents a positive externality, directly affecting the utility of the other by increasing their consumption of the public good AND, specifically generating a free-rider problem, since the strategy (S_1) always means increasing, although be a small portion of the good Y available for the consumption of both

[2] On the consumption of this type of goods, such as fresh air, forests, beaches, etc., environmental services have been identified, such as recreational or contemplative amenities, the health benefits they represent, and even their aesthetic value; same services for which although it is not easy to assess a price for their enjoyment, they are recognized as a consumer good.

[3] Public goods are consumer goods that do not express rivalry or exclusivity; open access resources have rivalry, but not exclusivity; congestible resources, present exclusivity, but not rivalry (space limit, quota) Invalid specified source .. The fact that public goods are not rivals, that is, what at any level of use for production, the marginal rate to supply it is zero; nor excluding, that it is not possible to exclude anyone from their consumption. It generates that the use of these goods is excluded from economic estimates, allowing the existence of market failures, particularly of free-rider; where one or more individuals consume a good or service without paying for it, generating inefficiency

individuals - as a public good - each one retaining its consumption of good X constant. Finally, that both individuals take the non-cooperative strategy (S_2), leads to a payment exit in which both players do not have access to the consumption of the public good Y, which could be seen as exhausted for the society of two individuals. The preference structure seen previously for non-cooperative games (Cioni, 2006), would suggest that, since there is talk of a positive externality over public goods, both players would be encouraged not to pay, hoping that the other player would do it for they, allowing a free consumption of the forest portion regenerated by the payment of the other player, evidencing a free-rider problem.

It is possible to take the analysis to instances of n-players, maintaining the same circumstances that lead to the form of the problem of the free-rider on all the individuals of a society except an individual i. In the case, an S company is assumed, with n number of people; Therefore, everyone is represented except the individual i as Sn − i, where we seek to maximize the social welfare function BS (X, Y):

i/S_{n-i}	$S_{n-i}(S1)$	$S_{n-i}(S2)$
$i(S1)$	$[U_i(X_i, Y^*), BS(X_{n-i}, Y^*)]$	$[U_i(X_i, Y_i), BS(X_{n-i}, Y_i)]$
$i(S2)$	$[U_i(X_i, Y_{n-i}), BS(X_{n-i}, Y_{n-i})]$	$[U_i(X_i, 0), BS(X_{n-i}, 0)]$

Prisoner's dilemma n players: free-rider externalities.

Comparing the payments of each column, when presented (S_1, S_2) is the social optimum, where all members of the economy cooperate by adding a $_{social}$ welfare function, in this case, with environmental purposes; on the other hand, when i adopts (S_2) and society (S_1), it is the classic free-rider problem, where the total of the Y pay available to all, is being assumed by society, while i continues to maximize its utility depending on the consumption of both X_i and Y_{n-i}.
The game reveals that regardless of the strategy that anyone chooses, (S_2) is the dominant strategy for i. Since the game is symmetrical, this argument holds that (S_2) is the dominant strategy for all people. Despite knowing that if someone chooses (S_2) and receives payment 0, and therefore, everyone will be in a worse situation than if they all take a cooperative attitude (Ordeshook, 2003), in this case friendly to the environment. In addition, with everyone paying their fees, each person would maximize their utility based on consuming Xi, Y *, which is considerably better than receiving Y = 0, as when everyone chooses (S_2), remembering what: $Y * = \Sigma Y_n > Y_i$.
It could be thought that knowing the above, and in this particular case, that the consequences are to lose the total number of forests in a society, would lead individuals to act cooperatively to achieve the optimum of social welfare. However, if n is very large, thinking about cooperative strategies can be especially difficult, since the task would be to coordinate the voluntary actions of all people, and to achieve this type of coordination requires leadership and some minimal form of organization, which is out of this model (Ordeshook, 2003).

4. Limits and possible solutions

Since the game points out that different environmental problems can be approached from the analysis of externalities, the possible solutions evoke the same instances as the internalization of external effects: the estimation of taxes or subsidies, and the regulation of property rights (Mass -Collel, Whinston, & Green, 1995). Although this solution is not presented as a simple task; as one of the main limitations is that unless society or its leaders can apply sanctions of some kind, it will not be achieved, as it is common that each member who initially contributes to some voluntary agreement, at the same time, shares an incentive to desert unilaterally (Ordeshook, 2003).

The difficulty in solving this problem comes from the number of people who must reach an agreement in society, where everyone should be incentivized by a benefit when performing this or that action. Already Hume, I noticed the difficulty of this purpose in the treaty of human nature:

> It is very difficult, and indeed impossible, for a thousand people to reach an agreement on some kind of action: it is difficult for them to design so complicated, and even more difficult to execute; while each one seeks a pretext to rid himself of the problem and of the expense, to put all the burden on the others (Hume, 2001, p. 382).

Finally, although it is pointed out that agreements for large groups of people are not reached, there is doubt about the possibility of whether an agreement could be reached between games of few participants, for example, the case of a game that models the strategies of choice to reach a bilateral international agreement between two countries; remembering that the competitive game between two players under the analysis of externalities, although it is not resolved by the lack of incentives, the solution for these externalities from the microeconomic theory is to resort to the establishment of property rights and in more general to government intervention as a regulatory body with the power to enforce its authority, as with the establishment of mandatory fees, taxes or subsidies (Mass-Collel, Whinston, & Green, 1995). In the case of international agreements, the main limitation is summed up by the lack of an authority body with sufficient capacity to force both countries to assume cooperative strategies (Cioni, 2006). Specifying this problem, in many cases the players, seen as countries linked to some international agreement, cannot sign binding contracts and the reasons can be the following:

1. The strategies of the players are unobservable to the mediator or the legal executor of the contracts (if it exists);
2. There are no effective ways to punish players who infringe a contract either because the available punishments are inadequate or because it is very difficult to detect any violation, as is the case of common goods offered by environmental services;
3. The strategies of some actors involve the violation of inalienable rights (such as sovereignty, food security and the like) (Mayerson, 1991).

Collective action to resolve the prisoner's dilemma, then, requires more than cooperation and agreements in good faith. This dilemma can find its solution only if there is a means to reach and properly apply the agreements at all levels. The philosophers of the social contract like Hobbes and Locke, already saw a similar condition in which the lack of any authority would deprive society of order, which would result in a state of war, in which man in his natural state would act by its own means promoting violence, insecurity, theft and death to become the basic means of subsistence, excluding arts, industry, study and other desirable situations that ensures a state of order, where the government allows to safeguard the integrity of individuals (Ordeshook, 2003).

Conclusions

With the analysis presented on the possible economic-environmental equilibrium from the application of the neoclassical economic theory, it can be concluded that said equilibrium, although not unattainable, since formally there is a verifiable point where under the order imposed by some authority could direct the course of actions; in practical terms, this balance is only in the best approximate case, since it depends on the individual decision-making of the economic agents, as shown, they lack the necessary incentive to direct them towards cooperative decision-making regarding to the environment.

Under this argument, environmental economics assumes as its own the concepts and principles established by neoclassical theory (Martínez de la Torre, 2008); that is, despite openly promoting a friendly management of natural resources, the analysis is still done in a framework of choice, based on increasing or maintaining the utility that is obtained directly from nature; where it has been seen that some tools of the neoclassical models can be extended to evaluate the relations between economy and the natural world (Brown & Timmerman, 2015); with the limitation that once the relations between society and nature, between two (or more) agents with respect to a natural element become conflicts of interest, it ceases to be an economic problem to become an ethical problem and, therefore, therefore, it can clearly be argued that it is not a failure in economic theory, since it even generates the possible solutions from a well-established institutional framework, answering what different authors have questioned regarding neoclassical theory as responsible for a problem that It is out of it.

So, being a problem of interest rather than an economic problem, arguing, for example, for an intrinsic value in plants, animals and in general in ecosystems, is a philosophically problematic position: then assume that a species or an ecosystem as a whole , is aware, is unsustainable (Singer, 1984); but it does not prevent seeking rational solutions within the moral philosophy that studies and influences social behavior.

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