

Games of Cooperation, Coordination, and Conflict¹

(two players for two strategies)

I. Problem

A. Introduction

Many of the interactions between social agents are immersed in relationships that depend on the configuration of the payments or net benefits that each one receives as a consequence of their actions and the actions of others. In a large number of opportunities, the interactions occur between two individuals (a buyer and a seller, an employer and a worker, two neighbors who share a platform or water source, the owner of the land and a sharecropper, etc.), and that's why game theory is used. A theory for examples in which you have two players and two possible actions or strategies. The most popular example of game theory is the so-called "prisoners' dilemma," which we will describe later.

In the case of the use (extraction) and management (administration) of natural resources, we can think of multiple instances in which two players face the dilemma of taking one of two possible decisions, and depending on the decisions of the other player, each one will be affected positively or negatively. A farmer may choose to make changes in his production system to improve his short-term income, but this can generate effects of erosion or contamination of the water of his neighbor who occupies the bottom of the basin. A user of an irrigation system may decide to provide manpower to maintain an irrigation channel at a personal cost and receive the benefits of his action, but those benefits may also be perceived by another user who has made the decision not to provide labor for the maintenance of the common irrigation district. Two users of that irrigation district must, at some point, negotiate the distribution of the available water, and for this they can use criteria such as their needs according to their cultivated area or the size of their family; These decisions will have direct consequences for each one of them.

The possibility that the exchange ratio between the two players produces optimal results individually and collectively is determined by the way in which payments are given according to each player's action. In some cases, the payments or results of the actions are organized in such a way that without redirecting the actions of the players, the individualistic strategy of each one leads to a social and individually optimal result (coordination problem). On other occasions,

¹¹ Translated from Juan-Camilo Cardenas and Pablos Andres Ramos (2006) Manual de juegos economicos para el analisis del uso colectivo de los recursos naturales, Centro Internacional de la Papa https://economia.uniandes.edu.co/files/profesores/juan_camilo_cardenas/docs/Archivos%20para%20descargar/MANUAL_JUEGOS_CARDENAS_RAMOS.pdf

these results vary as the strategy of individual optimization of each player leads to a result that is not satisfactory for either player (cooperation dilemma). And on other occasions, the outcome depends on each player's bargaining power, and increases in a player's well-being occur at the expense of the other's welfare losses (negotiation or concussion problem). Many instances of social interaction relationships can be framed in these categories, and the purpose of the games presented in this section is to show and test the differences in the results according to the configuration of the payments or benefits.

B. Purpose of the Games

With the two-player games for two strategies that we include in this module, we want to show how the configuration of the payments establishes a substantial difference in the final result of the game and in the comparison between the individual well-being and the collective welfare of the players.

The general form of the four included games is described in the following payment matrix which shows the possible winnings for player 1 and player 2 according to their decisions. The player 1 can choose between two actions or strategies - "up" and "down" - and player 2 can choose between "left" and "right". The gains are described in the cells of the matrix, where the value of the left will be the gain for player 1 and the value of the right of the cell will be constituted by the payments for the player 2. For example, if the player 1 chooses "up" and the player 2 chooses "right", the first one gets a payment of d and the player gets a payment of a. In this matrix, symmetrical payments have been included, in the sense that for the situation "up, left" or "down, right" the players obtain the same gain, and when they opt for opposite actions they obtain (a, d) or (d, a) symmetrically. However, it is possible to build these payment matrices with any other combination of payments, depending on the particular question or situation

As in the other games in this manual, the values assigned to the points, in monetary or non-monetary payments, must have a real value for the players, so that we can expect rational behavior.

		Player 2	
		LEFT	RIGHT
Player 1	UP	(b, b)	(d, a)
	DOWN	(a, d)	(c, c)

The games that are going to be described next assign different values to a, b, c and d in order to induce the situations of coordination, cooperation or conflict that may occur in the exchange relations.

The implementation of the games will be, in all cases, very simple: two people must choose one of their two possible actions simultaneously and without being able to communicate or coordinate their actions previously. Depending on their decision and the decision of the other player, they will be able to know what individual winnings they earned.

The analysis of the results must be both normative and positive. In the normative aspect, we must evaluate, for the particular values of these four values, which is the most appropriate social and individual result. We have the possibility of applying several criteria, but perhaps the two most common and relevant are equity and science (total size of the cake produced). In terms of science, the basic criterion is that we can add the two payments of each cell and evaluate in which situation, of the four possible, the highest level of social or collective gains occurs.

Regarding equity, we must evaluate the difference between the payments of the two players in each cell. These two criteria allow us to evaluate with normative criteria which of the four possible outcomes is what we believe to be socially optimal.

The positive analysis is a bit more complex but equally important. By positive analysis we refer to having a point of reference of what we believe will happen in the game, as a prediction and not as a normative judgment, when the two players choose freely and can coordinate their actions with the other.

For this analysis, game theory uses the concept of Nash strategies and Nash equilibrium [from the seminal work of John Nash, mathematician and Nobel laureate in economics for his contributions to the use of game theory for the analysis of the economic interactions and the work that originated the game theory of Morgentsern and von-Newmann (in 1947)].

In very simple terms, Nash's strategy refers to the best choice or best response of a player based on what he believes will be the best response from the other player. The Nash equilibrium results, then, from the combination of the Nash strategies of the players, i. e. it is considered that a Nash equilibrium has been established when, at that point, all players are choosing their Nash strategies respectively. Later, with the particular cases of games that we include, we will make a description of these concepts.

C. Economic Analysis Models

The four games present, then, different results in terms of Nash equilibrium and social optimum, and that is the basis of the wealth of the set. In the following matrices, the Nash equilibria appear in the cells marked in shading with diagonal lines, and the social optimum in cells with a yellow background.

For Game 1: The game of the invisible hand

Player 2

Player 1

	N	R
N	(4, 4)	(2, 10)
R	(10, 2)	(8, 8)

The way we analyze the game is as follows: think of player 1, who must consider two scenarios: if player 2 chooses N or if they choose R. If player 2 chooses N, player 1 should choose R, since $10 > 4$. If player 2 chooses R, player 1 should choose R again, because $8 > 2$. This means that Nash's strategy of 1 is to choose R no matter what the player 2 chooses.

Now let's think about player 2. They must also consider two scenarios: when 1 chooses N and when 1 chooses R. If 1 chooses N, 2 should choose R, since $10 > 4$, and if 1 chooses R, 2 should choose R again, since $8 > 2$.

We have, then, that both players should choose R as their Nash strategies, and therefore in (R, R) we have a single Nash equilibrium. Second: when evaluating the social science of each case, we see that in (N, N) there are $4 + 4 = 8$ units of social welfare; in (N, R) or (R, N) there are $10 + 2 = 2 + 10 = 12$ units, while in (R, R) there are $8 + 8 = 16$ welfare units, this being the maximum social welfare in the game. As a result, the Nash equilibrium and the social optimum of this game coincide, which would tell us that in applying it we should observe a majority of people choosing the R option, and observing how their individual interest as a whole leads to the maximization of common well-being.

This is why we call this game the "invisible hand", in which the sum of individual interests leads to common interest without the need to build additional institutions or rules of the game. This figure of the invisible hand is common in the analysis of competitive markets, in which each agent interacts looking for their own welfare, and that healthy and fair competition between the buyers and sellers of a market produces a balance in which prices and the amounts negotiated in the market maximize the welfare of both, individually and socially.

Let us now observe other games in which this result does not occur and, instead, there are differences between the individual and collective interest, which generate social losses.

For Game 2: The Cooperation Game

Player 2

Player 1		N	R
	N	(4, 4)	(1, 6)
	R	(6, 1)	(2, 2)

With the same criterion of the previous analysis, we see that player 1 should choose N when player 2 chooses R ($6 > 4$), and they should also choose N when player 2 chooses N ($2 > 1$). The same logic is given in this case for player 2, and therefore we have again that the Nash equilibrium of this game is reached when both players choose (N, N). The difference between this game and the previous one is that, in this one, Nash's strategy produces a balance that is not socially desirable. We produce only $2 + 2 = 4$ welfare units, when we clearly see that $4 + 4 = 8$ units could be produced if the two players had chosen R. This paradoxical result has been called the "prisoner's dilemma", but we prefer call it "social or cooperation dilemma". The dilemma is that the individual rationality of each player leads to a result that neither of them would have preferred. The fundamental reason is that the best response of each one to any of the scenarios is to play N, because 6 or 2 is better than 4 and 1, respectively. In this game, it is very clear that cooperating would be equivalent to playing R, but this only generates benefits when the other player also chooses this strategy, and if the rules of the game do not allow the two players to commit to it before deciding, the best choice is not to cooperate, that is, to opt for N, losing the possibility of obtaining an individual and collectively desirable result.

For Game 3: Game of Coordination and Conventions

Player 2

Player 1		N	R
	N	(1, 1)	(1, 0)
	R	(0, 1)	(4, 4)

Let's move, now, to another interesting variation. In this case, using the same logic of analysis, we see that each player should choose, as Nash's strategy, to do exactly what the other does, but this generates two possible Nash equilibria. Think of player 1: if 2 plays N, 1 should choose N ($1 > 0$), but if 2 chooses R, 1 should also choose R. Since the matrix is symmetric, we can say the same of player 2 and we see that there are two equilibria, in (N, N) and in (R, R). However, one of them (R, R) is socially superior.

When this game is applied, we would expect that most players tend to focus on equilibrium (R, R), since we could assume that there is a social "convention" in which everyone preaches, individually and collectively, that $(4 + 4)$ is better than $(1 + 1)$.

For Game 4: Negotiation Game

		Player 2	
		N	R
Player 1	N	(9, 1)	(0, 0)
	R	(5, 5)	(0, 0)

This last game has been called negotiation since, basically, it concentrates on the problem of dividing 10 units between two players. In its simplest version, we include only two options, to divide (5, 5) or (9, 1), although we could think of a matrix of many more columns for other possibilities.

Note that, in this game, player 2 has the option to make that total amount disappear if they disagree with the division that player 1 chooses. If Player 2 chooses R, the payouts for both players will be 0. If they choose N, it will be in the player's hands to divide those 10 points between the two. Let's analyze the strategies that are in balance. Player 1 has Nash's strategy to choose N ($9 > 5$) if the other one chooses N, but is indifferent if 2 chooses R. For player 2, Nash's strategy is different. If 1 chooses N, 2 should choose N, and if 2 chooses R, again their best strategy is to play N. Then, we go back to player 1, who when studying the best strategy of player 2 (play N) should choose N, producing the result (9, 1) as Nash equilibrium.

Now, both (9, 1) and (5, 5) are social optimums, since they generate a well-being of 10 units. But in terms of equity they differ substantially, and they differ from the previous three games. That is the reason for this last game. If the players participating in this decision include an equity component in their preferences, they may have some incentive not to choose the Nash equilibrium of the prediction and rather obtain the result (R, N) = (5, 5).

In this game, it is particularly important to follow the sequence, i. e. that player 1 first chooses if they want R or N, and that player 2, knowing what player 1 chose, decides N or R.

II. Assembling the Game or Experiment

Note: the experimental design of these two-by-two games is inspired by Holt, Charles and Monica Capra (2001).

A. Experimental Design

The following four games show different possibilities of payment configuration that respond, respectively, to situations of coordination, cooperation, coordination and conventions, and negotiation or conflict. There are many more possible games, according to the relative values of a, b, c, and d. The attention to these is because they represent a large proportion of relevant social interaction situations that create the problems that occupy us here.

B. Sample Size (suggested minimum)

In order to generate the minimum playing conditions in which each player previously does not know who they will interact with in the group, it is recommended that at least six players (three pairs) be present, so that these couples can be randomly assigned such that each player finds it difficult to predict with whom they will play. However, with such small groups, the problem always arises that the last couple cannot maintain anonymity. Therefore, a group of 10 or more people would be the most appropriate to achieve the minimum conditions of play.

C. Session Design (N players, T rounds)

Up to 30 people can play each session. The game works in pairs: each person must make a decision and their earnings are determined both by this decision and by the decision of the person with whom they play. A game session consists of five rounds of each of the game versions (as there are four games, in total, there would be 20 rounds), which lead to different results and to deepen the analysis of the coordination in the groups. The total number of rounds played by the group will be 15.

D. Necessary Materials

The team must have a sufficient number of cards in order to give a red and a black card to each player, regardless of the number or the letter, since the game only takes into account the color of the card.

E. Type of Participants

All types of people are able to participate.

F. Estimation of the incentives and payments to participants

The payment matrix is constructed so that at the end, according to the points obtained by each participant, a payment in cash is made. It is possible to play this game in a single round or in several if you want to look at the effect of learning and reciprocity over time. If it is played in several rounds, it is possible to assign the pairs in a random way in each round or assign the same pair in all rounds. Each modality has different effects according to the question of interest. One way to assign points for payments could be this:

41-51 points	10 dollars
31-40 points	8 dollars
21-30 points	6 dollars
1-20 points	4 dollars

A good way to construct the relationship between payment and points is to use a day of work in the place where the games are made, and the number of rounds that you want to use the same game, as a reference for the amount of payment.

III. Tools and Logistics

A. Type of Room

It is necessary to have a room in which the moderator can observe all the participants, who will be seated. To read the instructions, it is necessary that the room has a board on which the moderator can write the winnings of the players according to their decisions.

B. Field Team

To carry out this game, it is necessary to have a moderator and a monitor.

The roles of the moderator are:

The moderator is the person in charge of welcoming the participants to the exercise, commenting on the intention of the game, reading the instructions and answering the questions that the players have about the exercise.

After answering all the questions that arise from the exercise, the moderator will proceed to begin the five rounds of game 1, then the five rounds of game 2, and finally the five rounds of game 3.

Apart from reading the instructions to the group, the moderator is in charge of guiding the players during the exercise and answering their questions. For this it is necessary to remain neutral and to avoid influencing - through answers or attitudes - the decisions of the players.

The roles of the monitor are:

The monitor is the person in charge of recording the data of each of the players during each round; they will do so on a monitor sheet (we will present the sheet format later). They are also in charge of supporting the moderator during the exercise, especially when materials are being given to participants.

Similar to the moderator, the monitor should act neutral during the exercise in order to avoid influencing the decisions of the players.

IV. Necessary formats to carry out a game session

A. For the Explanation of Instructions

In this game, there are three different ways for players to make a profit; therefore, it is necessary that the moderator write on a board, during the explanation, the possible winnings for the players in each of the forms of the game.

Game 1

Your earnings are:

- 4 if you choose black and the other person chooses black
- 10 if you choose red and the other person chooses black
- 2 if you choose black and the other person chooses red
- 8 if you choose red and the other person chooses red

Game 2

Your earnings are:

- 4 if you choose red and the other person chooses red
- 6 if you choose black and the other person chooses red
- 1 if you choose red and the other person chooses black
- 2 if you choose black and the other person chooses black

Game 3

Your earnings are:

- 1 if you choose black, it doesn't matter what the other person chooses
- 4 if you choose red and the other person chooses red
- 0 if you choose red and the other person chooses black

Game 4

Player 1's earnings are:

- 9 if you choose black and the other person chooses black
- 5 if you choose red and the other person chooses black
- 0 if the other person chooses red

Player 2's earnings are:

- 1 if you choose black and the other person chooses black
- 5 if you choose red and the other person chooses red
- 0 if you choose red

B. For each one of the players

Date, Place and hour: ___/___/___

Player Number: ____

Game and Round	Your Decision	Partner's Decision	Your Earnings

This is the format that is given to the players. The information that must go in each cell of the table is very simple: first mark the number of the game and the round; then, the player's personal decision with the initial letter of the color - (N) black, (R) red-. The same to note the other person's decision and the earnings.

C. Facilitation Instructions to Introduce the Games

For the moderator

Introduction: Thanks for being here. [Greeting and introduction of the facilitating team. If necessary, talk about the general objective of the research and the funder, the general project, how long the game session will be, the relevance of the study, etc.].

The following exercise is a different and entertaining way to participate actively in a study about people's economic decisions. Depending on the decisions you make today, you may earn a certain amount of money or prizes, so it is important that you pay close attention to these instructions.

You may wonder why money is used in these exercises. Money is used because the exercise requires people to make economic decisions; that is to say, that they are decisions with consequences for the pocket, as it happens in the reality. At no time is money expected to be a payment for participating in the study, nor is it the sole reason for your participation.

Explanation of the Game: We will participate in a game in which each one of you will interact with another person present in this room. Each one of you must have two cards: one red (diamonds or hearts) and one black (spades or clubs). Neither the number nor the suit of the card matter, only the color. You must choose one of these letters and put it against your chest, covered, to indicate that you have already made your decision, but without anyone knowing what decision you made. Your earnings will depend on both the letter you choose and the letter chosen by others.

After you choose your letter, lift it up against your chest, do not let it be known which letter you chose. Once everyone has made their choice, we will assign the pairs at random. At that time, you will be able to know what your earnings are according to your decision and that of the other.

The moderator will assign the pairs. Ensuring order, they will ask a person to lift their letter, and then choose another person from the group; they will be the players 1 and 2 of each pair. The moderator will continue this way until all the people in the group have shown their letter and know what their score was.

For Game 1

- You will earn 4 points if you choose the black card and the other person chosen by the moderator also chose the black card.
- You will earn 10 points if you choose the red card and the other person chooses the black card.
- You will earn 2 points if you choose the black card and the other person chooses the red card.
- You will earn 8 points if you choose the red card and the other person also chooses the red card.

For Game 2

- You will earn 4 points if you choose the red card and the other person chosen by the moderator also chooses the red card.
 - You will earn 6 points if you choose the black card and the other person chooses the red card.
- You will earn 1 point if you choose the red card and the other person chooses the black card.
- You will earn 2 points if you choose the black card and the other person also chooses the black card.

For Game 3

- You will earn 1 point if you choose the black card, no matter what the other person chooses.
- You will earn 4 points if you choose the red card and the other person chosen by the moderator also chooses the red card.
- You will earn 0 points if you choose the red card and the other person chooses the black card.

For Game 4

In this game, first all the players that have a number 1 must make a decision; That decision is made public and then the number 2 players decide. The profits are distributed as follows:

For Player 1

- You will earn 9 points if you choose the black card and the other player also chooses the black card.
- You will earn 5 points if you choose the red card and the other player chooses the black card.
- You will earn 0 points if the other player chooses the red card, no matter what your decision was.

For Player 2

- You will win 1 point if you choose the black card and the other player also chooses the black card.
- You will earn 5 points if you choose the black card and the other player chooses the red card.
- You and the other player will earn 0 points if you choose the red card.

Does anyone have any questions?

D. Informed Consent

It is necessary that you, as participants, review and sign the acceptance or informed consent form. In this sheet, we assure you that we will manage all the information collected in the exercises in a confidential manner; In addition, we point out that participating in these exercises does not present any risk. Your signature signifies that you are aware of and have accepted the project and the exercises that will be carried out [read the informed consent form to the whole group, aloud]. If you agree to participate, please fill in your acceptance form, and do not forget to write your player number on it.

For the monitor: Recording Sheet for Player Decisions

For this game, the facilitators must fill out the decision record sheets. For this you must bear in mind that five rounds are played for each exercise and that the number of pairs will be determined by the number of participants chosen or summoned. This is an example of a record sheet for the five rounds of the game in a group involving 22 people.

CARD FOR THE MONITOR

Place: _____

Date: _____

Hour: _____

Game	Round	J1	J2	R/R	N/N	N/R R/N	
1	1						
		2					
		3					
		4					

	5					

Sequence of the Experiment

1. Introductions of the Field Team/Facilitators
2. Introductions of the Participants
3. Instructions Lecture
4. Explanation of the Experiment
5. Explanation of the informed consent
6. Game
7. Pay the Participants

V. Digitally Capturing the Data

The data from this game can be captured while the monitor assigns the pairs that are uncovering their cards. This is a game in which decisions are made public; the monitor can record the results on a board, and then count the total of pairs of each possible option (N- N, R-R, N-R / R-N) to elaborate the analysis and the socialization of the results.

VI. Session of a Game, Example of how to Digitize the Data

For a group of 22 people, in which the five rounds of the first three games were played, the results were as follows:

Game	Round	Pair Frequency			Decision Frequency			
		RR	NN	RN/NR	R	N	% R	% N
1	1	10	0	1	21	1	95.5	4.5
	2	8	0	3	19	3	86.4	13.6
	3	8	2	1	19	3	86.4	13.6
	4	10	0	1	21	1	95.5	4.5
	5	8	0	3	19	3	86.4	13.6
2	1	1	9	1	3	19	13.6	86.4
	2	0	3	8	8	14	36.4	63.6
	3	0	8	3	3	19	13.6	86.4
	4	0	8	3	3	19	13.6	86.4
	5	1	9	1	3	19	13.6	86.4
3	1	7	0	4	18	4	81.8	18.2
	2	10	0	1	21	1	95.5	4.5
	3	10	0	1	21	1	95.5	4.5
	4	8	0	3	19	3	86.4	13.6
	5	7	0	4	18	4	81.8	18.2

VII. Data Analysis

For Game 1:

In this game, the Nash equilibrium and the social optimum are achieved when the two players choose the red card; this game is used with an objective to measure coordination within groups to make informed decisions. The dominant strategy is to choose the red card; the analysis of the data showed that the majority of the decisions were inclined towards the red card (more than 85% in the five rounds).

For Game 2:

This game exemplifies the prisoner's dilemma; The dominant strategy of the players is the black card. The Nash equilibrium is reached at the point where the decisions of the two players is the black card; The social optimum is that each player decides on the red card. The analysis of the data showed that most of the decisions were based on the black letter, that is, not cooperating.

For Game 3:

Game 3 has two Nash equilibria: both players decide to play with the red card or with the black card. The social optimum of the game was to play the red card; In the example, in all the rounds of this game most of the decisions were for the red card. The classic example of this situation is that of two drivers who are face to face in a road with only two lanes. Everyone can choose to drive on their right or on their left. If they choose opposite actions, a collision occurs with much lower net results for both. If each one chooses the same as the other, they have better payments and one balance is superior to the other. Driving on the left in India or on the right in Colombia will represent, then, the respective Nash equilibrium. If the game is in Colombia, driving on the right is a Nash equilibrium with payments above the Nash equilibrium of driving on the left - say, because of the previous experience of the two players and the ease with which they play- .

VIII. Presentation of the Results

Type of data presented to the whole group:

- Decision averages
- Percentage of plays equal to the Nash equilibrium, and percentage of plays equivalent to the social optimum (percentage of decisions close to these options)

VIII. Material to Photocopy

Each player must be given a recording card with a format of five rounds for each of the games (see the next page).

Date, Place and hour: ___/___/___

Player Number: ____

Game and Round	Your Decision	Partner's Decision	Your Earnings

Date, Place and hour: ___/___/___

Player Number: ____

Game and Round	Your Decision	Partner's Decision	Your Earnings

Date, Place and hour: ___/___/___

Player Number: ____

Game and Round	Your Decision	Partner's Decision	Your Earnings

Date, Place and hour: ___/___/___

Player Number: ____

Game and Round	Your Decision	Partner's Decision	Your Earnings