

**The Game Theory,  
Its Influence in Strategic Decision-Making**

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Economics book.

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# **INDEX**

**I. INTRODUCTION**

**II. CONCEPTION OF THE GAME THEORY**

**III. PRINCIPLES OF THE GAME THEORY**

**IV. THE PRISONER'S DILEMMA**

**V. THE TROLLEY DILEMMA**

**VI. STRATEGIC DECISION-MAKING**

**VII. THE AUCTION THEORY**

**VIII. GAMIFICATION**

**IX. THE GAME THEORY ANTITHESIS**

**X. CONCLUSIONS**

**XI. BIBLIOGRAPHY**

## **I. INTRODUCTION**

Although the Game Theory constitutes an arduous, difficult and complex theme, it is extremely interesting. This theory was designed in 1944 by Morgenstern & von Neumann, and has been complemented by outstanding economists and mathematicians (Nobel Laureates in Economy, due to their respective contributions to this scientific branch).

The Game Theory is essentially microeconomic and integrates with the Theory of Consumer Choice, and the Theory of Producer Behavior, considering that it justifies how strategies, tactics and actions don't depend only on the rational behavior of agents and competition in the markets, rather these are strongly influenced by the possible behavior of others, when facing certain events or due to the possible reactions of others. In that sense, the Game Theory explains why strategic behavior prevails over the optimizer one, overcoming the Neo-Classical Microeconomic Theory.

The principles of the Game Theory are: a) make decisions according to the circumstances and/or the possible behavior of others, b) implement non-cooperative or cooperative strategies, and c) achieve a microeconomic equilibrium.

Likewise, this theory has been analyzed by emblematic examples such as the prisoner's and the trolley dilemma.

**In the first case**, there are two persons arrested for committing a misdemeanor, who are interrogated separately. Each one must decide whether to: a) don't collaborate with the other detained (denouncing him), or b) collaborate with his partner (not accusing him).

In the long run, there are possible only two equilibriums:

**1. The least optimal:**

No one cooperates with the other (both betray).

**2. The optimum:**

Nobody confesses (mutual cooperation).

The assumptions of this hypothetical case also apply to: two groups of buyers in an auction, two corporations in a competitive market, two political parties in a parliamentary vote and two nations at war, among others.

While **in the second case**, a trolley goes straight to mow down five people tied in the rail, however, if a switch is pressed, this small train will change its route, killing one person, tied in the other way.

This kind of situation proves that it is always possible to consider a third non-traditional option, in order to collaborate with those involved. The right decision is to dump the trolley, saving the six citizens tied, but risking the life of one passenger of the small train.

Even more, these scenarios can be replicated in a corporation. The management must decide whether to cancel several projects or a relevant one, anticipating in both cases a massive withdrawal of investors. The third option or “exit way” is to continue with all the projects, assuming considerable risks and expecting support from the majority of the shareholders. In that sense, the Game Theory corroborates that there is always a third non-traditional option, too risky, more political than technical, whose favorable results must materialize in the long-term.

Therefore, these guidelines influence over strategic decision-making, going beyond the microeconomic scope and reaching the macroeconomic level. In the Chapter VI. Strategic Decision-Making, it is argued that controversial policies implemented by the Federal Reserve (2008-2014) constitute an excellent reference of the application of these premises.

In addition, there are two relevant extensions of the Game Theory:

## **1. The Auction Theory:**

The strategies of the parts distort the prices of goods and services and/or can move the balance towards the selection of non-ideal contractors or suppliers. Moreover, the price of stocks is significantly affected by corporative and investment strategies, which minimize business valuations and expectations about performance of the respective financial instruments.

## **2. Gamification:**

Used in the academic and business environment. This management style ratifies that always the best option is to get the cooperation of those involved, in order to fulfill the corporate or institutional objectives.

Otherwise, the dynamics of the well-known monopoly game contradicts the Game Theory. In the Chapter IX. The Game Theory Antithesis, it is explained why its operation goes against this microeconomic theory, emphasizing that the end of the game isn't a proper equilibrium, because in the long run its conditions will affect the winner, being this situation unsustainable.

Finally, it is convenient to reiterate that the Game Theory has an essence (strategic behavior) and certain principles (decisions based on circumstances and/or behavior of others, strategies of cooperate or not cooperate, and achieve of a microeconomic equilibrium), which indicate that in the long-term, the agents must cooperate to attain the best possible agreement (win-win), joining this perspective with the approach of integrative negotiations (win-win).

## II. CONCEPTION OF THE GAME THEORY

This theory is abstract, broad, complex and diffuse. It was designed in 1944 by the economist Oskar Morgenstern and the mathematician John von Neumann. Subsequently, the Game Theory was complemented by John Harsanyi<sup>1</sup>, John Nash<sup>2</sup> and Reinhard Selten<sup>3</sup> (winners of the Nobel Prize in Economics 1994), Robert Aumann and Thomas Schelling<sup>4</sup> (Nobel Laureates in Economy 2005), and Alvin Roth and Lloyd Shapley<sup>5</sup> (Nobel Laureates in Economy 2012).

Even more, this theory is a branch of mathematics and economics, which allows analyzing, evaluating and predicting strategic behavior, without using managerial models. It is also a relevant microeconomic principle that examines the interactions between individuals, groups, corporations and institutions, who make difficult decisions, immersed in complex processes (games), where prevail certain incentives and expectations, and finally, the different results are aimed to achieve economic equilibriums.

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<sup>1</sup> He included economic reasoning in philosophy, morality and politics.

<sup>2</sup> He introduced the notion of less optimal equilibrium (when the participants don't collaborate).

<sup>3</sup> He extended this theory to chess and poker (obviously, the strategies are based on the responses and actions of the competitors).

<sup>4</sup> They applied this theory to explain how nations perform in warlike conflicts.

<sup>5</sup> They developed the Matching Theory, which affirms that there are failures in transactions, due mainly to information problems (it isn't a matter of prices). In other terms, the exchanges aren't well done because people don't have enough information to make the best decisions.

The Game Theory goes beyond the Neo-Classical Microeconomic Theory, since it justifies strategies, tactics and actions, that don't depend only on the rational optimizing behavior of agents and competition in the markets, rather these are powerfully influenced by the possible behavior of others, in the face of the circumstances and/or due to the possible reactions of others.

In the same way, this theory integrates with the Theory of Consumer Choice and the Theory of Producer Behavior.

The Consumer Choice Theory supports these aspects:

1. At a subconscious level, there is a utility or welfare function, which is satisfied by the consumption of goods and services, free time, work, leisure activities, savings, investments, etc. Constantly, it is also maximized by taking into account: income, certain determinants (cost, effort, time, resources, risks, ethical considerations, opportunities, expectations, etc.), and present and future consequences.

2. As a result of this maximization process, each person within his possibilities (mainly the budget constraint, no one can spend more than he earns), must choose a consumption basket from a variety of options to satisfy his needs.

3. Every decision of consuming generates an additional level of satisfaction in the utility or welfare function, depending on the individual's assessment.

4. The maximization of welfare based on budgetary restrictions and other determinants takes place on a daily basis, at a subconscious level. Moreover, this is the foundation of human rationality: to make rational choices considering complex circumstances and different limitations, especially, financial restrictions.

5. People's satisfaction depends on their utility function. As income rises, consumers increase their spending. However, the individuals also become accustomed to their new spending limit (which never reaches a point of satiety), and in the long run they will not be happier.

6. The acceptance or rejection of job offers, and commercial or business proposals, comes from the assessment of income expectations vs. other elements of the utility function. Based on this evaluation, the income expectations will not always satisfy the consumers' preferences.

7. Saving is a deferred consumption. Its purpose is to improve the future well-being, or to leave part of the financial resources to others (generally, the descendants), taking into account certain events (lack of money to buy products at a determined time, need of cash to face uncertainty or shortage of resources, and absence of long-term opportunities).

8. If the supply of certain products decreases, they will continue to be sold, although at higher prices, because these goods are vital to the welfare of some citizens.

9. Risk aversion, principles, moral values and ethics, also influence the way people satisfy their needs. Gary Becker, the 1992 Nobel Prize Laureate in Economics, basing his studies on the microeconomic Theory of Consumer Choice, proved that criminal behavior is rational.

Broadly speaking, the Consumer Choice Theory confirms that people are constantly making decisions, which leads to consuming and saving, in order to satisfy needs and maximize their utility function.

Nonetheless, the Game Theory states that consumption and savings decisions, among others, depend on facts and/or the possible responses of others.

The emblematic case is the stock market.

If people think that others will buy massively the stocks of some corporation, influencing a possible increase in the prices of these financial instruments, then they will not sell those that they have, and maybe will acquire more of them. In other terms, the decisions of buying and selling stocks depend more on the expected behavior of other investors than on their true profitability.

Regarding the Theory of Producer Behavior, it indicates that companies maximize their profits, using corporate strategies and optimizing their resources.

However, the Game Theory confirms that production, sale and marketing decisions are also influenced by the possible responses of competitors and consumers.

For example, when a corporation realizes that its competitors can decrease the production of some item, this company will increase the manufacturing of that product. In that sense, the decision to produce more depends mainly on the expected behavior of the competitors (they will decrease their production) and/or consumers (they will acquire the goods), than from the profit margins of the referred product.

**Conclusion on the conception of the Game Theory:**

The essence of the Game Theory is that decisions are not influenced only by maximizing profits, minimizing losses and meeting needs. Rather, **these depend considerably on the circumstances, events, facts and mostly on the possible behavior of others.**

### III. PRINCIPLES OF THE GAME THEORY

The foundations of the Game Theory are the following:

1. Its pillars are: human rationality, optimizing behavior of agents, circumstances, events, facts, expectations about the behavior of others and the possible results.

In that sense, individuals seek to maximize their profits or minimize their losses, mainly considering the possible reactions of others. Therefore, strategies, tactics and actions depend on the facts, attitudes and responses of others.

2. The gains of one person can constitute losses for the other (zero-sum game).

3. Often, each one decides between two vital strategies:

3.1 Not cooperating.

3.2 Cooperating.

4. Although it is possible not cooperating, the best strategy is to cooperate, in order to resolve disputes and preserve long-term agreements.

5. The strategy of cooperation or collaboration is used when at least one of these conditions is met:

5.1 The information available is reliable, accurate and truthful.

5.2 The parts are interested in solving a problem and/or ending a conflict.

5.3 There are more than two involved.

5.4 Negotiations are under way.

5.5 Coalitions or groups are formed to achieve certain objectives.

5.6 There are third parts or other influential “players” interested in solving this problem.

6. The game ends if an optimal microeconomic equilibrium is reached, which is characterized by these aspects:

6.1 It is impossible to change the results. Neither the affected, nor other agents can implement strategies, tactics or actions to modify the outcomes.

6.2 Those involved don't have incentives and/or valid reasons to protest or attempt to change this final situation.

6.3 At least one individual maximizes his well-being or a group fulfills its objectives.

7. There are also cases of less optimal equilibrium (John Nash's contribution), in which the best strategies are applied to those of the adversaries (distributive or win-lose approach), and any of these results are obtained:

7.1 All minimize their losses.

7.2 Some maximize their profits and others minimize their losses.

8. A less optimal microeconomic equilibrium is distinguished by:

8.1 The inability to alter the results.

8.2 The absence of incentives and/or valid reasons to question or modify this situation.

8.3 All minimize their losses or some maximize their profits and others minimize their losses.

9. The ethic forces to give up on exaggerated aspirations and reach viable agreements.

### **Conclusion on the principles of the Game Theory:**

The principles of this theory are: a) make decisions according to the circumstances and/or the possible behavior of others, b) implement non-cooperative or cooperative strategies, and c) achieve a microeconomic equilibrium (situation in which the results can't be altered, there aren't incentives and/or valid reasons to object or try to modify the outcomes, and at least one person or group fulfills its objectives).

#### **IV. THE PRISONER'S DILEMMA**

The classic example of the Game Theory is the prisoner's dilemma or the case of two captives who committed a misdemeanor. Each prisoner is interrogated separately and asked: Is your partner guilty?

The options are the following:

**1. Both betray:**

Lack of cooperation with each other.

**2. The first prisoner accuses the other, who doesn't betray his partner:**

One doesn't cooperate, but the other does.

**3. The first prisoner doesn't accuse the other, but is betrayed by his partner:**

One cooperates, but the other doesn't.

**4. No one confesses:**

Mutual cooperation.

Each inmate must decide whether or not to collaborate with his partner, as presented in this table:

**Table 1. The Prisoner's Dilemma**

		2nd Prisoner	
		Accuses his partner	Doesn't accuse his partner
1st Prisoner	Accuses his partner	1. Both betray, <u>lack of cooperation with each other.</u>	2. The first prisoner accuses the other, who doesn't betray his partner, <u>one doesn't cooperate, but the other does.</u>
	Doesn't accuse his partner	3. The first prisoner doesn't accuse the other, but is betrayed by his partner, <u>one cooperates, but the other doesn't.</u>	4. No one confesses, <u>mutual cooperation.</u>

Source: Own construction.

These are the consequences in each scenario:

**Table 2. The Prisoner's Dilemma**

		2nd Prisoner	
		Accuses his partner	Doesn't accuse his partner
1st Prisoner	Accuses his partner	1st prisoner: 6 years in prison. ①	1st prisoner: 1 year in prison. ②
		2nd prisoner: 6 years in prison.	2nd prisoner: 10 years in prison.
	Doesn't accuse his partner	1st prisoner: 10 years in prison. ③	1st prisoner: 2 years in prison. ④
		2nd prisoner: 1 year in prison.	2nd prisoner: 2 years in prison.

Source: Own construction.

**In the first case**, the Nash equilibrium or a less optimum one was reached, because:

1. The results can't be modified.
2. As both have been denounced, no one has arguments to appeal the decision of the authorities.
3. When they were sentenced to six years in prison, both minimized their losses (with respect to the second and third situation, in which anyone could be sentenced to 10 years).

There isn't an equilibrium **in the second and third case**, considering that the accused may retaliate against the other, can change his testimony and accuse his partner. These actions will benefit him (reducing his penalty from 10 to 6 years) and at the same time, increase the punishment time of the non-collaborating prisoner. In other words, there prevail some conditions that prevent an equilibrium. The following stand out:

1. It is feasible to alter the results.
2. The denounced prisoner has a motive and the ability to change this situation.
3. The betrayed prisoner hasn't minimized his losses.

**In the fourth case**, an optimal microeconomic equilibrium was obtained (different from the Nash less optimal one, because this approach is integrative or win-win), taking into account that:

1. The results can't be modified.

2. As the detainees weren't betrayed, no one has incentives to accuse the other, nor valid reasons to appeal the decision of the authorities.

3. When they were sentenced to two years in prison, both minimized their losses (with respect to the first, second and third situation, in which anyone could be sentenced to 6 or 10 years).

Again, the equilibrium situation is characterized by: a) the impossibility of changing the final outcomes, b) the absence of incentives and/or capacity to protest or change the results, and c) the maximizing of profits or the minimizing of losses, for each participant.

Certainly, the equilibrium means the end of the game, as represented in this table:

**Table 3. The Prisoner's Dilemma**

		2nd Prisoner	
		Accuses his partner	Doesn't accuse his partner
1st Prisoner	Accuses his partner	<b>EQUILIBRIUM</b> 1st prisoner: 6 years in prison. (1)	1st prisoner: 1 year in prison. (2)
	Doesn't accuse his partner	1st prisoner: 10 years in prison. (3)	<b>EQUILIBRIUM</b> 2nd prisoner: 2 years in prison. (4)
		2nd prisoner: 6 years in prison.	2nd prisoner: 10 years in prison.
		1st prisoner: 1 year in prison.	2nd prisoner: 2 years in prison.

Source: Own construction.

However, there isn't communication between the detainees and due to the risk that the other can betray, the most likely option is the first (each one accuses his partner).

Although if both have reliable, accurate and truthful information (they fully trust each other, know that they can accuse the traitor and/or they are allowed to talk), the prisoners will prefer the mutual cooperation option in order to minimize their losses, preserve their friendship and continue working together in the long-term.

This also happens when two associations or strategic alliances, with the same power and authority are involved. For example:

Two groups of buyers at an auction.

Two corporations in a competitive market.

Two political parties in a parliamentary vote.

Two nations at war.

Economists and mathematicians have extensively used the Game Theory to explain: conflicts, political decisions, trade disputes, wars and negotiations.

There is some consensus that in the long run, agents are forced to negotiate and cooperate, to end these complex games.

After more than half a century of conflict and armed confrontations between the Colombian government and a guerrilla group, the parts recognized the need to end the violence and began negotiations to reach a peace agreement. Obviously, those involved must cooperate to end these “destructive games”.

Moreover, Robert Aumann corroborated that:

1. A country has several options against the hostilities of another.

2. If it is supported by influential nations, it has immense probabilities of reaching a satisfactory agreement that can avoid a warlike conflict.

Thomas Schelling demonstrated that the Cold War was based on the logic of the Game Theory, explaining that the parts' strategies were based on the ability to threaten and retaliate, which provided greater benefits than confrontation and resistance to military attacks. He also indicated that the objectives of each foreign power were:

1. Gain recognition as military leader.
2. Protect their territories.

Otherwise, Alvin Roth and Lloyd Shapley have supported a research program known as the Matching Theory, which argues that failures in some markets (mainly public services such as health and education) are caused by barriers that impede communication between bidders and users, instead of pricing problems.

Alvin Roth has designed algorithms and models for organ donation networks and entries of students, obtaining impressive results in: a) the England Program for Kidney Exchange, and b) the schools admissions (New York City and Boston's public school system). This has allowed to increase significantly the number of compatible organ donors and school entries (90% of reduction in the proportion of students, who were accepted in institutions that they didn't want).

Lloyd Shapley introduced the concept of Shapley's value in Game Theory (tested analytically). He argues that in a coalition, each member contributes in a different way to the achievement of the objectives, and therefore, the benefits will not be equal.

For example, in a company, profits will be distributed like this:

**Profits (P) of each worker (w):**

$P_w = 50\%$  of his contribution to corporative profits.

**Profits (P) of the owner (o):**

$$P_o = \sum_{i=1}^n P_{wi}$$

n: Number of workers (i:1...n).

$P_{wi}$ : 50% of contribution to corporative profits of worker i.

Each employee will receive only 50% of his contribution to the company profits, while the owner of the company, who assumes the risks, manages the business and owns the physical capital, will get the sum of the 50% not granted to the workers.

In a commercial organization, the benefits aren't distributed equally and influenced by different facts: the risks faced by entrepreneurs, the labor merits of each employee, etc.

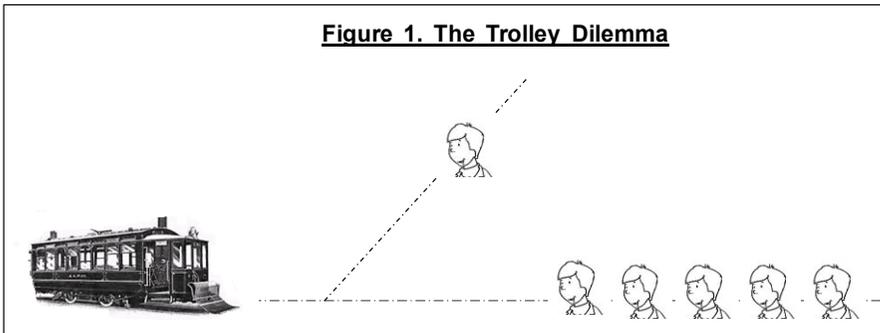
### **Conclusion on the prisoner's dilemma:**

In this example, the Game Theory confirms that reciprocal cooperation is the best option for the benefit of the parts (win-win), since if some collaborate and others don't, then a situation of equilibrium will not be reached and subsequently, it can be achieved a less optimal equilibrium, in which prevails the position of minimizing losses (instead of maximizing gains).

## V. THE TROLLEY DILEMMA

Another classic example of the Game Theory is the trolley dilemma (which has many variants). In this, it is evident that there are diverse perspectives to face the situations and it can always be considered a third non-traditional option.

As consequence of a terrorist attack, a trolley lost its brakes and goes directly to mow down five citizens that are tied. However, if a switch is pressed, the small train will go another way, but there is a person tied, as shown in this illustration:



Source: Own construction.

The options are:

1. Not cooperating with the five persons, allowing the vehicle to continue its course.
2. Cooperating with them, pressing the button that will change the route of the small train.