COOPERATIVE VS. NON-COOPERATIVE GAMES: A COMPARISON OF SOLUTIONS AND IMPLICATIONS

Stefan Mladenoski
Faculty of Economics, American University of Europe-FON
North Macedonia
mladenoski.stefan@outlook.com

ABSTRACT
Game theory is considered a key framework in understanding the market economy. That is exactly why the comparison between cooperative and non-cooperative games and their outcomes is significant. Namely, when it comes to what constitutes a cooperative game, as the name suggests, it is a game in which two or more players make decisions together. In contrast, a non-cooperative game is one in which each player independently decides how to play their move. The aim of this paper is to compare the solutions and implications of cooperative and non-cooperative games, which will be explained through theory and practical examples. The methodological approach used in this paper is based on theoretical analysis, modeling of games, and examining the solutions obtained from the structure of the games. Cooperative and non-cooperative games both involve strategic decision-making by rational players, but they differ fundamentally in the role of communication and the possibility of binding agreements. While cooperative games allow for coalition formation and the achievement of efficient outcomes, non-cooperative games focus on individual strategies in conditions of limited trust, which often lead to less optimal but more realistic equilibria. The results of this comparison highlight the importance of selecting the appropriate game model when analyzing strategic situations, depending on the level of trust, the potential for cooperation, and the nature of interests among players. This opens space for further research toward the development of hybrid models and their practical application in areas such as economic markets or international relations.

Keywords: *Cooperative games, Non-cooperative games, Nash equilibrium*

JEL classification: *C71, C72, D43*

1. INTRODUCTION

When defining game theory, it is important to note that it represents an analytical tool for explaining the phenomenon of strategic decision-making, that is, situations in which the decisions of one player directly depend on the expected or actual choices of others. The models used in game theory are mostly abstract. Nevertheless, this abstraction becomes an advantage, as it allows for a clear representation of reality and applicability across various situations in economics. Furthermore, the line between theoretical and applied game theory is often blurred, with many formal models serving as the foundation for the development of practical scenarios. Mathematics is frequently used as a tool in game theory to facilitate this adaptation, to precisely define concepts, evaluate the consistency of ideas, and explore the implications of assumptions (Osborne, 2004).

Historically, game theory began to develop after World War II, with the foundational work of John von Neumann and Oskar Morgenstern (1944, as cited in Osborne, 2004). In addition, it was further advanced by John Nash, who introduced the concept of equilibrium in non-

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cooperative games (Nash, 1950). Nash equilibrium has become one of the most influential concepts in economics and the social sciences, enabling the modeling of strategic interactions without requiring direct coordination or communication among players. On the other hand, the development of cooperative game theory, especially through concepts such as the Shapley value (Shapley, 1953) – focuses on the fair distribution of gains among coalition members, considering their relative contributions.

Thus, game theory is divided into two main branches: cooperative and non-cooperative. While both originate from a common logic of rational behavior, they differ in terms of communication, the possibility of binding agreements, and the structure of interaction (Osborne, 2004). This distinction is highly relevant for the analysis of strategic situations in the real world, as it reflects the difference between situations in which players can communicate and make joint decisions and those in which they are forced to act independently, without influencing the choices of others (Leyton-Brown & Shoham , 2008).

Cooperative games are those in which players have the chance to form coalitions and agree on collective strategies that maximize joint payoff. In this context, players are motivated to coordinate and negotiate to achieve stable and optimal outcomes. For example, in economics, cooperative games are often used to model scenarios such as labor unions, cartels, or other forms of collaboration within industries (Tadelis, 2013), where players (e.g., companies) can agree on prices, output levels, or resource allocation.

In contrast, non-cooperative games refer to situations where players lack the ability or incentive to form coalitions and make joint decisions. Here, each player focuses solely on individual payoff and optimizes their strategy in a competitive environment. The outcomes of non-cooperative games—such as the Nash equilibrium—represent situations where each player chooses a strategy that maximizes their own payoff, given the strategies of the others. In this state, no player has an incentive to unilaterally change their strategy. However, these outcomes are often stable but not necessarily cooperative, especially in environments where communication and trust are limited (Grabisch, 2021).

Understanding this distinction is fundamental when choosing the most appropriate model for analyzing a specific situation, as each type of game is based on different assumptions, constraints, and outcomes. Through the analysis of cooperative and non-cooperative games, one can gain deeper insight into how decision-making varies depending on collaboration, competition, and the strategies of players.

The primary objective of this paper is to compare cooperative and non-cooperative games, focusing on their solutions, assumptions, and practical implications. By analyzing selected models and practical examples, the paper aims to highlight the key similarities and differences between the two approaches, as well as to identify the conditions under which one is more suitable than the other. From a methodological perspective, the research relies on theoretical analysis and formal modeling, employing fundamental game theory concepts such as Nash equilibrium and the Shapley value. (Nash, 1950; Shapley, 1953).

Additionally, this paper seeks to examine concrete scenarios relevant to economic and social contexts, to demonstrate the real-world implications of choosing one type of game over the other. Structurally, the paper is divided into seven sections. The first section introduces the basic theoretical concepts and definitions related to cooperative and non-cooperative game theory. The second section presents a comparative analysis through a specific theoretical

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explanation of both cooperative and non-cooperative games. This is followed by the next two chapters, in which a broader practical comparison of both types of games is provided, aimed at providing a comprehensive understanding of the importance of choosing the appropriate game structure. The fifth section discusses side-by-side comparison and practical implications while at the same time suggesting directions for potential hybrid approaches. The paper concludes with a summary and proposals for further research.

2. THEORETICAL FRAMEWORK

Key concepts

Games with two players

Games with two players are basic analytical models when we talk about game theory. They serve as for deeper understanding of strategic interaction between both parties (Osborne, 2004). Additionally, they define theoretical borders for formalizing behavior in situations with confrontation or potential cooperation. This type of game is classified as cooperative or non-cooperative, depending on whether the players can enter binding contracts (Tadelis, 2013). In a cooperative context, the involved parties decide together for maximization of the common outcome, while in the non-cooperative context, each actor independently chooses a strategy in the direction of optimizing individual gain (Osborne, 2004; Leyton-Brown & Shoham , 2008).

N-players games

Games involving more than two players introduce a higher degree of complexity due to the exponential growth in possible interactions, coalitions, and strategic configurations (Tadelis, 2013). These games are especially relevant for analyzing collective decision-making, coalition formation, and the fair allocation of outcomes. In cooperative game theory, analytical tools such as the Shapley value, the core, and various coalition stability concepts are employed to evaluate each player's contribution and determine equitable distributions (Shapley, 1953). The Shapley value assigns a value to each player based on their marginal contribution to every possible coalition they could be part of, reflecting how much value a player adds on average to different combinations of players. In the non-cooperative domain, strategic behavior is typically modeled through generalizations of Nash equilibrium in multi-agent settings, where each participant seeks to optimize their own utility while accounting for the strategies of others (Nash, 1950; Osborne, 2004). As the number of players increases, concerns such as stability, trust, and coordination become increasingly important (Tadelis, 2013).

Games with a variable number of players

In certain contexts, the number of participants is not fixed; players may enter or exit the game or coalition at different stages (Osborne, 2004). These variable-player games demand a distinct theoretical approach, as they introduce dynamic and often unpredictable coalition structures. Such games require consideration of entry and exit costs, dynamic stability, resource reallocation, and coalition flexibility (Myerson, 1991). The analysis of these environments often involves extended concepts such as the dynamic core, time-dependent Shapley value, and adaptive strategic frameworks. The underlying challenge is to ensure fair and stable outcomes even as the composition of participants changes over time.

Strategies

A strategy is defined as a complete plan of action that a player follows throughout the game (Osborne, 2004). Depending on the nature of the game, the strategy may be either simple or complex, specifying the player’s action in every possible contingency. Strategies are often categorized as either pure (deterministic), where a player selects a single specific action, or mixed (probabilistic), where choices are made according to a probability distribution over available actions (Tadelis, 2013).

Payoffs
The payoff denotes the value a player receives because of the strategies chosen by all participants (Myerson, 1991). It typically reflects the player's utility, profit, or another quantifiable benefit, and serves as the core measure of individual rationality and motivation. Payoff functions underpin the evaluation of strategic behavior and are essential to determining optimal responses and outcomes in any game-theoretic context (Tadelis, 2013).

Equilibrium
The concept of equilibrium is central to game-theoretic analysis. It identifies outcome configurations in which no player has an incentive to unilaterally deviate from their chosen strategy (Osborne, 2004). The most prominent notion is the Nash equilibrium, defined as a set of strategies - one for each player - such that no player can improve their payoff by independently changing their strategy, given the strategies of the others (Nash, 1950). Equilibria may arise in pure or mixed strategies and serve as a predictive and normative tool for analyzing stability and rational outcomes in strategic environments (Tadelis, 2013).

3. COOPERATIVE GAMES

Definition

Cooperative games are a form of strategic interaction in which the players have opportunities to conclude binding agreements and to form coalitions. In this context, instead of analyzing the individual strategies of each participant, the focus is placed on groups of players (coalitions) and their ability to achieve a joint profit (Osborne, 2004; Mayerson, 1991). The analysis assumes that the agreements between the players are fully binding and enforceable (Tadelis, 2013; Grabisch, 2021).

Characteristics

Cooperative games are characterized by several essential features:

- Formation of coalitions: Players can group together and form coalitions, which allows for collective action and maximization of common interests.
- Binding agreements: It is assumed that once agreements are reached, they are fully enforced, which makes the model suitable for analyzing stable long-term coalitions (Osborne & Rubinstein, 2016).
- Characteristic function: For each possible coalition, a value is defined that represents the potential gain that coalition can achieve on its own, independent of the rest of the system (Myerson, 1991).
- Distribution of gains: A central issue in cooperative theory is how the gains from cooperation are distributed among the members of the coalition. To that end, various concepts are used, such as core, Shapley value, nucleolus, and bargaining set (Shapley, 1953; Tadelis, 2013).

Example

As an example, for the cooperation game, the author's interpretation of the glove game is presented “the glove game” (Osborne & Rubinstein, 2016).

Let us consider a game in which there are 3 players. Players 1 and 2 possess a right glove, and player 3 a left glove. Possessing a pair of gloves is worth 1. The players must cooperate to generate profit. Thus, we have

$$\mathrm{v(S)} = \begin{cases} 1 \text{ if S includes at least one right} - \text{glove player } (1 \text{ or } 2) \text{ and player } 3 \\ 0 \text{ otherwise} \end{cases}$$

Table 1: The values of v(S) for the glove game

S	{1}	{2}	{3}	{1,2}	{1,3}	{2,3}	N
v(S)	0	0	0	0	1	1	1

(Source: Made by the author)

Now we compute the Shapley value for the glove game presented above. In theory, the Shapley value is a vector in $\mathbb{R}^N$ given by

$$\Phi(N, v) = \frac{1}{n!} \sum_{\sigma \epsilon G(N)} m^{\sigma}$$

In this formula, it is important to explain the key symbols where:

In the tables above, the following symbols are used:

- N refers to the set of all players participating in the game.
- $G(N)$ denotes the set of all possible permutations, or different possible orders, in which the players can form a coalition.
- σ $(sigma)$ represents one specific permutation or order of players from the set $G(N)$.
- v stands for the characteristic function, which assigns a value or payoff to each possible coalition of players.
- m^{σ} indicates the marginal contribution of the players according to the specific permutation σ, showing how much value each player adds when joining the coalition in that order.

Then, for our example, we obtain:

Table 2: The values of v(S) for the glove game

order σ	m_1^{σ}	m_2^{σ}	m_3^{σ}
{1, 2, 3}	0	0	1
{1, 3, 2}	0	0	1
{2, 1, 3}	0	0	1
{2, 3, 1}	0	0	1
{3, 1, 2}	1	0	0
{3, 2, 1}	0	1	0
$\Phi(v)$	$1/6$	$1/6$	$4/6 = 2/3$

(Source: Created by the author, theoretical basis in Shapley, 1953*)*

Note that in the glove game, the core is the point {0,0,1}. Hence, in general, the Shapley value does not lie in the core.

4. NON-COOPERATIVE GAMES

Definition

A non-cooperative game is a formal representation of strategic interaction where players make individual decisions without the possibility of forming binding agreements or coalitions (Fudenberg & Tirole, 1991). Each player acts independently, seeking to maximize their own payoff, considering the actions of others. The focus lies on predicting individual behavior in situations where outcomes depend not only on one's own decisions but also on the strategies chosen by others. In contrast to cooperative games, non-cooperative game theory analyzes outcomes that arise purely from strategic choices, without external enforcement of cooperation (Myerson, 1991).

Characteristics

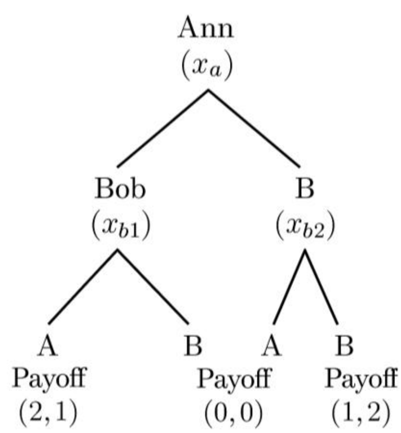
Non-cooperative games possess several defining features:

- Individual Decision-Making: Each player selects their strategy independently, aiming to maximize their own profitability (Binmore, 2007).
- Strategic Interdependence: A player's payoff is influenced not only by their own decision but also by the decisions of all other players (Tadelis, 2013).
- Game Representation: These games are typically represented in normal (strategic) form, through payoff matrices, or in extensive form, which models sequential moves via game trees. (see pictures below)
- No Binding Agreements: Players cannot make enforceable contracts or promises; coordination, if it exists, must emerge endogenously from equilibrium behavior.
- Equilibrium Concept: The central solution concept is the Nash Equilibrium, in which no player can gain by unilaterally changing their strategy given the strategies of others (Nash, 1950).

Picture 1: Game matrix representation

$A\backslash B$	A	B
A	2,1	0,0
B	0,0	1,2

Picture 2: Game tree representation



(Source: Meeting game (Fujiwara-Greve, 2015)

(Source: Tree for the sequential decision meeting game (Fujiwara-Greve, 2015)

Example
An example of this type of game is the classical prisoner's dilemma. There is one representation of the prisoner's dilemma.

Namely two guys have been arrested by the police. Since there is not enough evidence to convict them, the police interrogator offered the following deal the following deal to each of them:

If you testify that the other guy is guilty (defect), you will be set free and the other will be imprisoned for 3 years; unless he also defects, in which case you both will be imprisoned for 2 years. If you both keep your mouth shut (cooperate), each of you will serve 1 year in prison.

Each prisoner knows that the same offer has been made to the other. Moreover, each one knows that the other knows that he knows, and so forth. This assumption about the game is called common knowledge and is a necessary prerequisite to have a game of complete information. Without common knowledge, the behavior of prisoners could be different.

The situation is formalized as a strategic game $G = (N; A; u)$, where the two players in $N = \{p_1; p_2\}$ can play actions from $A = \{C, D\}$, where C stands for Cooperate with the other player (don't speak to the police) and D stands for Defect (make a deal with the police to testify against the other prisoner). After playing the players will get payoffs denoted by the utility function $u = (u_1, u_2)$, where $u_i: A \mapsto \Re$ is depicted in Table 3. Since players are awarded years in prison (they get punishment rather than reward), the payoffs take a negative sign, to denote that more years are worse (non-preferable) to less years.

Table 3: The values of prisoner's dilemma game

u_1, u_2		p_2 player	
		Cooperate	Defect
p_1 player	Cooperate	(-1, -1)	(-3, 0)
	Defect	(0, -3)	(-2, -2)

(Source: Created by the author)

The codomain of u_i is the set of all potential payoff values that can result for player i from the different combinations of strategies chosen by all players in the game.

5. COMPARATIVE ANALYSIS: COOPERATIVE VS NON-COOPERATIVE GAMES

Overview of Main Similarities and Differences

Cooperative and non-cooperative game theory represent two major strands within the broader field of game theory, both offering analytical tools for understanding strategic interactions among rational players (Osborne & Rubinstein, 2016; Myerson 1991). While they share a foundational reliance on the rationality of agents and formal mathematical models to describe and predict behavior, they differ significantly in their treatment of communication, enforceability, and the structure of interactions.

In both frameworks, players are assumed to act strategically with the aim of maximizing their individual payoffs. Strategic interdependence is central, as outcomes depend not only on a player's own decisions but also on the choices made by others. Moreover, each framework seeks to identify stable outcomes through rigorous solution concepts such as the Nash equilibrium in non-cooperative games, or the core and the Shapley value in cooperative games (Nash, 1950; Shapley, 1953).

The primary distinction lies in the extent to which cooperation is permitted or enforceable. Cooperative games allow for the formation of binding agreements between players who can join forces and coordinate their actions to maximize collective benefits or in other words, to cooperate with each other. These games are typically represented in characteristic function form, which assigns a value to every possible coalition (cooperation) of players. Non-cooperative games, in contrast, assume that players act independently and cannot form enforceable coalitions. Interactions are modeled using strategic (or normal) form representations, in which each player's strategy is set, and corresponding payoffs are explicitly defined (Osborne & Rubinstein, 2016).

Another key difference concerns the treatment of trust, communication, and information. In cooperative games, players are assumed to be able to communicate freely, share information, and form binding agreements that ensure commitment to joint strategies. Trust is externally sustained through institutions or contracts, which legitimizes long-term cooperation and stability. On the other hand, in non-cooperative games, the lack of enforceable commitments implies that communication may be limited or strategically manipulated, and information asymmetries play a more central role. Players cannot rely on trust enforced from outside the game, and instead, must base their actions on the rational expectations of others' behavior. This makes the study of incentives, beliefs, and strategic uncertainty essential within non-cooperative models.

Trust, communication, and information problems

While the general contrasts between cooperative and non-cooperative games have been outlined, the dynamics of trust, communication, and information merit closer attention due to their central role in shaping strategic environments. In these terms, cooperative games explicitly assume that players can communicate, share private information, and enforce agreements - often through institutional or contractual mechanisms. These assumptions enable coordination, reduce uncertainty, and promote stable, mutually beneficial outcomes.

In contrast, non-cooperative games, however, model environments where such mechanisms are absent, unreliable, or strategically constrained. Players must operate under conditions of incomplete or asymmetric information, and communication - if it occurs - is often limited or used manipulatively. Trust is not externally enforced but must instead be incentivized internally, emerging (if at all) from the structure of the game itself. This endogenous development of trust and the absence of guarantees underscore the need for precise mechanism design, where systems must be crafted to align individual incentives with socially desirable outcomes despite informational and strategic barriers. As a result, the study of non-cooperative games places particular emphasis on the role of beliefs, signaling, and equilibrium behavior under uncertainty.

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Implications for Real-World Applications

Understanding the distinctions between cooperative and non-cooperative games carries significant implications for decision-making in real-world domains such as economics, politics, and negotiations. The applicability of one framework over the other often depends on the institutional context, the nature of interaction among agents (players), and the availability of enforcement mechanisms.

In economic contexts, cooperative game theory is especially relevant in situations where binding agreements can be established (Myerson, 1991). Examples include labor unions negotiating with employers, joint ventures between firms, or the formation of cartels where competitors coordinate prices or output. These settings allow for coalition formation and collective bargaining, making cooperative models suitable for analyzing stability, profit distribution, and incentives to remain within the coalition. In contrast, non-cooperative models are fundamental for understanding competitive markets where firms act independently, such as in pricing strategies, auctions, or oligopolistic rivalry. Here, the lack of enforceable contracts and the strategic behavior of agents necessitate a non-cooperative approach.

In political science, cooperative games are used to analyze coalition governments, party alliances, and international treaties, all of which rely on negotiated agreements and shared commitments. These situations typically involve explicit coordination among actors who align their interests toward common goals. Conversely, many aspects of political behavior, such as voting dynamics, strategic lobbying, or legislative bargaining, are better captured through non-cooperative frameworks. In scenarios like these, individual actors pursue their objectives independently, often within institutions that do not guarantee binding outcomes.

Negotiation scenarios also vary in terms of their cooperative or non-cooperative nature. When parties can make enforceable commitments - such as in trade agreements, diplomatic accords, or environmental treaties - a cooperative model is appropriate. Nonetheless, many real-world negotiations take place without enforceable commitments and in settings characterized by asymmetric information and low levels of trust. These are more accurately modeled as non-cooperative games, where outcomes depend on the strategic choices of each party and their expectations about others' behavior.

These distinctions help explain the growing interest in hybrid approaches that incorporate both cooperative and non-cooperative elements. In many strategic environments, actors may have partial communication, informal trust, or weak enforcement mechanisms. Hybrid models offer a more nuanced framework, reflecting the layered realities of trust, information, and institutional structure that shape outcomes across economic and political domains.

6. CONCLUSION

The theoretical distinction between cooperative and non-cooperative games lies at the core of game theory and reflects two fundamentally different approaches to modeling strategic interaction (Myerson, 1991; Osborne & Rubinstein, 2016). Throughout this study, we have examined how each framework conceptualizes the behavior of rational agents, the structure of their interactions, and the mechanisms through which outcomes are achieved. Cooperative games rely on the assumption that players can negotiate, form binding agreements, and share information transparently. This allows for joint strategy formation and the possibility of fair profit distribution through well-established concepts such as the Shapley value (Shapley, 1953). Non-cooperative games, by comparison, depict environments where players act on their own, frequently under conditions of limited or uneven information, and without enforceable agreements (Nash, 1950). This creates a fundamentally different environment in which equilibrium concepts such as the Nash equilibrium become central for analyzing behavior.

By providing a detailed comparison of cooperative and non-cooperative games, the study highlights that each approach offers unique strengths and is applicable under different sets of assumptions and institutional conditions (Myerson, 1991). Cooperative games are particularly well suited for analyzing long-term partnerships, labor unions, cartel formations, and other scenarios where sustained collaboration and enforceable commitments are possible. Non-cooperative games, on the other hand, excel in modeling competitive markets, political bargaining, and negotiation settings where actors pursue their self-interest without the possibility of forming binding coalitions.

Furthermore, this paper has shown that the presence or absence of trust, communication, and institutional enforcement critically influences which game-theoretic framework is appropriate for a given situation. In cooperative settings, trust and communication are external assumptions, supported by contracts or shared norms. While in non-cooperative games, trust must emerge endogenously from the structure of incentives, and communication is often strategic and non-binding. This distinction has significant implications for fields such as economics, where the design of institutions and market rules can be seen as efforts to shift environments from non-cooperative to cooperative dynamics (Myerson, 1991).

In addition, the growing complexity of real-world interactions has given rise to hybrid models that incorporate elements of both cooperative and non-cooperative game theory. These approaches recognize that in many settings, actors may partially cooperate while still retaining individual agency, or that communication and trust may exist in some dimensions but not in others. As a result, hybrid modeling frameworks allow for a more realistic representation of strategic environments in domains such as international negotiations, joint ventures, political alliances, and platform-based digital markets.

The implications of this research extend beyond theoretical interest. Understanding when cooperation is possible or likely, how incentives can be aligned in competitive environments, and what institutional mechanisms can foster stability and fairness is essential for policymakers, business leaders, and negotiators alike (Myerson, 1991). Whether analyzing mergers, labor disputes, environmental agreements, or legislative bargaining, the tools of game theory provide powerful insights into the dynamics of human interaction.

In conclusion, cooperative and non-cooperative game theory should not be viewed as competing paradigms but rather as complementary tools within a broader analytical framework. Their combined application offers a richer and more flexible approach to modeling complex strategic behavior, guiding decision-making processes in a variety of social, economic, and political contexts. Future research in game theory should continue to explore the boundaries between these models and refine hybrid approaches that better reflect the realities of strategic interdependence in an increasingly interconnected world (Myerson, 1991).

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