

# Individual decision, collective consequences: Game Theory and Covid-19

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The situation we are experiencing during the current Covid-19 pandemic confronts individuals with challenges of a different nature, highlighting, among many complex dynamics, the closely interconnected nature of certain decision behaviors. This concept can be analyzed by taking as a reference the issue related to the contagion containment measures, which have affected Italy, since the beginning of Covid-19 emergency (and continue to do so, indeed Italy has entered a strict three-day *lockdown* for Easter 2021 and many regions are still *red zones*, which means that they are still living under the restrictions that applied back in March 2020). Crucially, the reduction of the harm caused by the contagion would depend upon the collective adoption of those measures.

Compliance with these measures is considered essential in order to avoid as much as possible the free movement of people until the contagion factor has fallen below a certain threshold. At this point, a scenario begins to take shape in

which the behavior of a single individual has an impact not only on himself, but also, and above all, on other  $N$  individuals, where  $N$  refers to the number of potential people that a single carrier of Covid-19 (even asymptomatic) can infect.

This kind of dynamic, not only related to contagion, actually underlies many other situations in daily life in a society composed of individuals whose actions are almost always inevitably interconnected. From a behavioral point of view, **game theory** and, more specifically, the **prisoner's dilemma**, could offer us a lens through which to look at some specific aspects of the phenomenon under examination.

## **To Cooperate or not to Cooperate? This is the Dilemma**

**Prisoner's Dilemma** is a non-cooperative game in which the joint (but independent) choices of two players determine the payoff (i.e., the reward) of each of the two players. Its origins date back to 1950, when two

mathematicians, **Merrill Flood and Melvin Dresher**, developed the first version while serving at the **RAND Corporation** (Research AND Development), a North American think tank that offered support, in terms of analysis and research, to the United States military. Later, mathematician Albert W. Tucker formalized the idea, giving rise to the prisoner's dilemma as we know it today. According to some sources, it is likely that Tucker was confronted with John Nash, Nobel Laureate in economics and famous for his valuable contributions to game theory, during the formulation of the famous dilemma (**Peterson, 2015**).

The scenario proposed by the game is as follows (from **Kuhn, 2019**):

*Tanya and Cinque have been arrested for robbing the Hibernia Savings Bank and placed in separate isolation cells. Both care much more about their personal freedom than about the welfare of their accomplice. A clever prosecutor makes the following offer to each: "You may choose to confess or remain silent. If you confess and your accomplice remains silent I will drop all charges against you and use your testimony to ensure that your accomplice does serious time. Likewise, if your accomplice confesses while you remain silent, they will go free while you do the time. If you both confess, I get two convictions, but I'll see to it that you both get early parole. If you both remain silent, I'll have to settle for token sentences on firearms possession*

*charges. If you wish to confess, you must leave a note with the jailer before my return tomorrow morning."*

Kuhn, Steven, "Prisoner's Dilemma", *The Stanford Encyclopedia of Philosophy* (Winter 2019 Edition), Edward N. Zalta (ed.)

Here, the "dilemma" of the two prisoners is that whatever the other prisoner does, it is better to confess than to remain silent. However, the result they would get if they both confessed (a slight reduction in their sentence) is worse than if they both remained silent (a symbolic sentence for gun possession).

Let's look at it more analytically from Tanya's perspective. If Tanya confessed, two scenarios would be possible: the worst thing that could happen would be that Cinque would confess as well. Thus, Tanya would be convicted with a reduced sentence (**scenario A**). If, instead, Cinque remained silent, Tanya would be acquitted (**scenario B**).

If, however, Tanya does not confess, two different scenarios would be possible: the worst thing that could happen would be that Cinque confesses, making Tanya serve the maximum sentence (**scenario C**). If, instead, Cinque also did not confess, then Tanya would take only the token sentence (**scenario D**).

The confess strategy implies the possibility that either A or B would occur. The not confess strategy implies instead that either C or D would occur. In terms of personal utility (or payoff, which in this case is represented by the reduction in

years in jail) that Tanya can achieve, we will have:

$$B (5) > D (3) > A (2) > C (0)$$

Since the sum of **B + A**, which are the two scenarios associated with the **confess strategy**, is greater than the sum of **D + C**, which are the two scenarios associated with the **non-confess strategy**, the confess strategy is considered the dominant one. What has been said so far applies to Cinque as well, so we will have that, also for him, the dominant strategy will be confess (see Figure 1). Therefore, with the goal of maximizing their utility, two perfectly rational decision-makers would confess, thus finding themselves both in the lower-right quadrant. However, as can be seen from the figure, the best-case scenario for both is the upper-left quadrant (symbolic sentence). Put in these terms, the choice for the two prisoners is between cooperating (non-confessing strategy) and not cooperating (confessing).

		Cinque	
		Not Confess	Confess
Tanya	Not Confess	<div style="display: flex; justify-content: space-between; align-items: center;"> <span style="color: blue;">3</span> <span style="color: red;">3</span> </div>	<div style="display: flex; justify-content: space-between; align-items: center;"> <span style="color: blue;">0</span> <span style="color: red;">5</span> </div>
	Confess	<div style="display: flex; justify-content: space-between; align-items: center;"> <span style="color: blue;">5</span> <span style="color: red;">0</span> </div>	<div style="display: flex; justify-content: space-between; align-items: center;"> <span style="color: blue;">2</span> <span style="color: red;">2</span> </div>

**Figure 1** – The table of payoffs for both prisoners. The numbers represent the utility that the prisoners would gain because of the combination of their independent choices.

Let us now see what would happen if we applied this model to the situation in which each individual, during Covid-19 restrictions, has to make specific decisions. Starting from what was briefly mentioned in the introduction, and without wanting to go into the merits of the effectiveness of the measures proposed for the containment of the contagion, we can schematize the problem in the following way:

- 1) each individual can choose whether to comply with the rules imposed by the lockdown or transgress them;
- 2) each person chooses individually, but the result of his/her actions will also depend on what other people will do. Simplifying, we think of N decision-makers who must make a single choice: to cooperate (i.e., comply with the rules) or not to cooperate (i.e., transgress the rules). Starting from this schematization of the problem, we now try to imagine three possible scenarios that depend on the interaction between the choices of individuals.

**Mutual defection – lower-right quadrant in Figure 1 – Nobody cooperates:**

**Individual decision:** each decision-maker chooses according to his personal state of subjective need, without placing any constraints on his personal freedom.

**Collective consequence:** each decision-maker continues to lead his or

her life as normal, thus favoring the spread of the contagion in a small unit of time, greatly increasing the probability that he or she, or those close to them, will not be able to receive adequate care in the event of contagion associated with severe symptoms.

This is the situation in which both Tanya and Cinque confess (thus not cooperating with each other), both being sentenced with a reduced verdict (remember that, in Kuhn's formulation, Tanya and Cinque care much more about their own personal freedom than the welfare of the accomplice?).

**Mutual cooperation upper-left quadrant in Figure 1 – Everyone Cooperates**

**Individual decision:** each decision-maker chooses based on the collective state of need, giving up their personal freedom.

**Collective consequence:** each decision-maker minimizes his or her own travels, helping to contain contagion and greatly increasing the likelihood that he or she, or those close to them, will be able to receive adequate care in the event of contagion associated with severe symptoms.

This is the situation where both Tanya and Cinque do not confess (thus cooperating with each other), both being sentenced to a symbolic punishment.

**Free riding – lower-left and upper-right quadrants in Figure 1. For every citizen who cooperates, there is one who does not cooperate.**

**Individual decision:** some decision-makers choose based on the collective state of need, others based on their own subjective state of need.

**Collective consequence:** those who do not cooperate, in addition to not giving up anything in terms of personal freedom, benefit from the sacrifice made by those who cooperate (reduction, albeit partial, of the risk of not receiving adequate care in case of infection associated with severe symptoms). On the other hand, those who cooperate, in addition to making sacrifices in terms of personal freedom, see the impact of their sacrifices reduced, for themselves and for those close to them.

It is the situation in which one of the two prisoners do not confess (cooperating with the accomplice) when the other confesses (not cooperating with the accomplice). The prisoner who confesses gets out of jail immediately, while the other stays in jail longer than she would have in any of the other three possible scenarios.

At this point, it is necessary to introduce another fundamental concept to better understand how this model works: the Nash equilibrium. When two players are both in scenario lower-right quadrant (conviction with a reduced sentence), because they have both adopted the dominant strategy (i.e. not cooperating),

neither of them should change the strategy, unless the other one does that too. In fact, if Tanya and Cinque had both decided to confess, but then Tanya changed her mind and did not confess, if Cinque did not do the same, Tanya would serve the maximum sentence, whereas Cinque would get out of jail immediately. The same is true in reverse for Cinque.

This can be considered an equilibrium situation, in which neither prisoner is interested in changing unilaterally. As Nash himself said in an interview, equilibrium is created when no one can unilaterally improve their situation. And then he added that, “to change, you have to act together.” Extending this principle to the situation of anti-contagion behavioral restrictions, one can see how, in order to move from a state in which no one cooperates to one in which everyone cooperates, it would be necessary for everyone to cooperate together. In fact, if two hypothetical decision-makers N1 and N2, in a given moment, were not respecting the rules imposed by the lockdown, finding themselves in a situation of equilibrium, neither of them, individually, will have interest in isolating themselves by giving up their freedom, unless they both collectively decide to do so.



Photo by Liza Poor on Unsplash

What would happen, then, if the **Nash equilibrium** were broken and everyone switched from a non-cooperative to a cooperative state in the prisoner’s dilemma? The so-called **Paretian optimum** would be reached, i.e., a state of affairs in which it is not possible to improve one’s own situation without worsening that of the other. In fact, if both Tanya and Cinque were in the upper-left quadrant (symbolic punishment for both), but Cinque changed his mind and confessed, only Cinque would improve his condition (getting out of jail), but at the expense of Tanya, who would serve the maximum sentence. The same thing would happen if N1 and N2 were both complying with the lockdown rules and, suddenly, N2 decided to start living his life normally again. N1 would find him/herself uselessly facing the sacrifices of the lockdown, because these would have partially disappeared from N2, who, instead, would not be making any sacrifice.

Therefore, as it can be noticed, the Nash equilibrium possesses an intrinsic

force, having the power to maintain things stable over the time. Who would be willing to sacrifice first, cooperating, knowing that the other could exploit it to his/her advantage, deciding not to cooperate? On the other hand, the Paretian optimum, although it can bring a collective benefit which is higher than the Nash equilibrium, is intrinsically weak, in fact it is not an equilibrium. In this condition, the individual would be continually tempted by the possibility to stop cooperating, taking advantage of the fact that the other(s) are still doing so. This action would break the equilibrium because, subsequently, even those who were initially cooperative would stop, since it would be no longer convenient to them (they would only be exploited by those who do not cooperate). This type of dynamic harkens back to the concept of “tit for tat” (Axelrod’s tit for tat strategy) which can be found in the version of the prisoner’s dilemma with repeated interactions.

Taking a step further, we arrive at the Tragedy of the Commons model (for more on this see **Tragedies of Commons in Kuhn, 2019**), which we might consider a multi-player variant of the prisoner’s dilemma. This model tells us that, if the number of individuals who cooperate was even slightly higher (e.g., 60%) than the number of individuals who do not cooperate (e.g., 40%), and this was enough to ensure significant benefits for all in terms of contagion containment, this would be a Nash equilibrium. Those who are cooperating

would not want to stop doing so, because the advantage they would gain from greater freedom of movement would be cancelled out by the disadvantage associated with contributing to a health crisis, of which they and their loved ones could be victims. On the other hand, those who are not cooperating have no interest in ceasing to do so, since they are already enjoying the benefits of containing the contagion without having to make any effort to do so. Paradoxically, however, this situation is also a **Paretian optimum**, since it is not possible to improve one’s own situation without worsening that of the other. In fact, those who are not cooperating are already in the best possible scenario (enjoying the benefits without paying the costs), so they cannot improve further. On the other hand, if, for example, some of the individuals who were cooperating (say 20%) became non-cooperative, the effectiveness of the entire anti-contagion system would be compromised and there would be no benefits for anyone. At this point, we would have a certain number of people who are still cooperating (40%), sacrificing themselves unnecessarily, and a certain number of people who are not cooperating (60%) and, therefore, neither sacrificing themselves nor enjoying any benefit.

## **From Models to Reality**

**Theoretical models**, although fascinating and suggestive, are **simplifications of reality**. It is possible

that the proposed models do not describe at all what we have observed during the pandemic disease or that they describe it in a partial way. Certainly, it is highly unlikely that they can grasp the complexity of the whole issue, which would deserve much more in-depth analysis than this.

That said, let's try to think about what we could learn from these models. The tragedy of the commons could make us think of why we see, at times, a phenomenon of social stigmatization of people who "do not cooperate", that is, who are not respecting the rules imposed by the lockdown. This is an example of how the model does not capture the complexity of reality, as the reasons that lead a person to "not cooperate", breaking the rules imposed by the lockdown, can be the most disparate. The motivation to not cooperate could depend on an economic, emotional or health interest. A person who is "not-cooperative" may actually be confused about what rules to follow. Someone who does or does not cooperate may be not only an individual but also a company. And so on until we can list a number of other variables that would make the models described above progressively more complex. We should, therefore, be careful not to label people and behaviors as we would if they were variables in a theoretical model.

Another necessary clarification is that, in reality, people do not always behave as we would expect from two perfect utility

optimizers like our prisoners, Tanya and Cinque: the dominant "do not cooperate" strategy is not always the preferred option (see e.g. Andreoni & Miller, 1993). Finally, in game theory, the decision-maker can calculate his/her payoff exactly, because all information is given a priori. On the other hand, everyday reality more often than not presents uncertain and difficult-to-read scenarios. Decisions, therefore, end up being taken in a rather approximate manner and not at all rationally

**After all these considerations, can we still learn something about game theory at the time of Covid-19 restrictions? Probably yes.**

**Cooperation**, in addition of being the key to the success of a strategy aimed at achieving a common goal, may become necessary to our **survival**. In an interconnected system, where every decision we make, while remaining individual and free, has an effect on other individuals whose decisions will, in turn, have an impact on us, acting from a strictly individualistic perspective which may no longer be sustainable. In fact, what the current pandemic is clearly showing us is the level of interdependence reached by individuals on a global level.

Another thing we could reflect about is that being in a crisis situation could lead people to focus more on their urgent and immediate needs. Examples might include supermarket assaults, the rush for masks, and escaping high contagion

areas enhancing the risk of spreading the virus outside circumscribed territories. When one feels the threat of being without food, without protection from contagion or isolated in a hostile situation, whether these threats are real or only perceived, not focusing on one's immediate needs becomes difficult.

A further example can be found relatively to the **vaccination campaign**. Madhur Anand and Chris Bauch argue that people may perceive the vaccination in relation to its potential costs and benefits. Specifically, the costs can be seen in terms of **individual safety** and **side effects**, while the benefits of protection against the virus can be both **individual** and **collective**. In this scenario, one may be motivated to wait until all the others get vaccinated to reap the benefits of lower infection rate amongst the population.

**But as more and more people take this strictly individual decision, the risk of getting infected remains high for everyone.**

Finally, the experience we have had so far seems to suggest that, **in order to achieve high levels of cooperation during an outbreak**, certain behaviors must be forced through special laws. This shows how difficult it is, in reality, to get out of a **non-cooperative equilibrium**. And that's food for thought, isn't it? To cooperate or not to cooperate, that is the dilemma. Will this be one of the great challenges we will face in a world of individual decisions and collective consequences?



## References

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