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Individual and Collective Decision-Making During the Covid-19 Pandemic in Brazil: Simulations on Game Theory and the Tragedy of the Commons

Renan Gadoni Canaan (University of Sussex);

Mayra de Souza Pimenta (Universidade Federal de Minas Gerais);

Abstract:

This paper aims to address the decision-making process of individual and collective behavior during the COVID-19 pandemic in Brazil. To answer this research question, our analysis will make use of economic theoretical models, namely game theory and the tragedy of the commons, to simulate individual, firms, and collective behavior in the pandemic in Brazil. Analysis point that, according to the Prisoner's dilemma approach, citizens, as well as firms, are inclined to mutually defect from changing their behavior to comply with social distancing measures. Consequently, they will be worse off compared to a group-centered decision. Also, the framework on the tragedy of the commons predicts that individuals, taking self-centered decisions, opt out of the sanitary measures. This will lead to the depletion of the collective benefit, i.e. public health. Therefore, public intervention is justified to coordinate individuals' behavior because citizens are better off when everyone complies with social distancing measures.

Keywords:

COVID-19; game theory; behavioral models; tragedy of the commons; collective decision-making.

JEL Code:

D7 - Analysis of collective decision-making

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6.6 - Análise da formulação, implementação e avaliação de escolhas coletivas

1. Introduction

COVID-19 is the name defined by the World Health Organization (WHO) for the disease caused by the new Coronavirus SARS-CoV-2 (GORBALENYA et al., 2020). The features of this virus, such as the incubation period and the contagion capacity, caused a quick spread of the disease (SANTOS et al., 2020). The fast-paced transmission across continents led WHO to officially declare SARS-CoV-2 as Pandemic on March 11, 2020 (WHO, 2020).

The spread of the virus brought forward systematic changes in daily actions and, consequently, in the routines of States, organizations, and individuals. The pandemic demanded a global-wide campaign to slow the spread of the new coronavirus, including mask-wearing, hand washing, avoiding face touching, and maintaining social distance (VAN BAVEL, et al., 2020). Such a massive shift in individual and collective behavior has not been previously recorded in contemporary world history (SENHORAS, 2020a).

The first case in Brazil was attested at the end of February 2020 (CRODA and GARCIA, 2020). Alike other countries, the diffusion of the new coronavirus significantly impacted human relations, generating wide repercussions (SENHORAS, 2020b). The measures implemented in the country, aiming at social distancing, involved the suspension of in-place teaching and working, the closing of part of commerce, and the suspension of events. Social distancing entails measures that aim to reduce interactions in a community, comprising infected people who have not yet been identified and therefore are not isolated. The importance of such a measure is aggravated because the country has not adopted a comprehensive testing strategy. Thus, there may be great underreporting in the number of cases and deaths (AQUINO, 2020).

The sustainability of these measures depends on the establishment of social protection for vulnerable populations. Such public policies aim to guarantee the survival of individuals during restrictions on economic activities (AQUINO, 2020). Besides, the cooperation of individuals is also essential to the effectiveness of measures of social distancing, aiming to avoid the collapse of the health system in the country¹ (CANABARRO et al., 2020).

As the Covid-19 pandemic requires a significant behavior shift and imposes psychological burdens on individuals, social sciences can provide relevant information on the types of postures adopted and their consequences (VAN BAVEL et al., 2020). For being an emerging topic, there are no studies that shed light on the individual and collective decision-making during the pandemic in Brazil and this is a major gap in the state-of-art literature. Therefore, this paper aims to address the question: What are the individual and collective behaviors during the COVID-19 pandemic in Brazil? To answer this research question, our analysis will make use of economic theoretical models to simulate individual, firms, and collective behavior during this event.

Analysis point that, according to the Prisoner's dilemma approach, citizens, as well as firms, are inclined to mutually defect from changing their behavior to comply with social distancing. Consequently, they will be worse off compared to a group-centered decision. In addition, the framework on the tragedy of the commons predicts that individuals, taking self-centered decisions, opt out of the sanitary measures. This will lead to the depletion of the collective benefit, i.e. the public health. Therefore, public intervention is justified to coordinate individuals' behavior because citizens are better off when everyone complies with social distancing measures.

This paper is structured as follows. Section 2 discusses the methodology adopted to simulate the decision-making process during the pandemic, namely, the game theory and the tragedy of the commons. In section 3, we present the prisoners' dilemma and use this game to allegorize individual and business decisions during the pandemic. Also, this section debates the framework of the tragedy of commons applied to the COVID-19 pandemic in Brazil. Finally, section 4 concludes the paper, bringing forward reflections on the use of behavioral models to better understand this and (possible) future pandemics.

2. Methodology

2.1. Game theory

The game theory is a mathematical approach that allows for the investigation of conflicts of interest present in the decision-making between two options, cooperating or not cooperating (AXELROD and

¹ A recently published study showed that maintaining and strengthening measures of social distancing, quarantine, and isolation of positive cases was necessary to prevent the collapse of health systems in Brazil. (CANABARRO et al., 2020).

HAMILTON, 1981). It is a sufficiently coherent scientific theory for the construction of knowledge in the most diverse areas such as Economics, Politics, Biology, Psychology, and Sociology. (ALENCAR and YAMAMOTO, 2008).

The game theory is a reference for examining rational decision-making strategies in complex environments and with several agents (MONTEIRO, 2008). It is a theory that analyzes situations where the result of a player's action depends fundamentally on the actions of other players. Therefore, individuals, groups, or institutions make decisions by taking into account the decision-making process of other agents² (FIGUEIREDO, 1994).

In the game, there is a finite set of players, represented by $G = \{g_1, g_2, \dots, g_n\}$. Each player $g_i \in G$ has a finite set of options $S_i = \{s_{i1}, s_{i2}, \dots, s_{im_i}\}$, called pure strategies of the player g_i ($m_i \geq 2$). A vector $s = (s_{1j1}, s_{2j2}, \dots, s_{njn})$, where s_{iji} is a pure strategy for the player $g_i \in G$, is called a pure strategy profile. Thus, the set of all pure strategy profiles generates the Cartesian product:

$$S = \prod_{i=1}^n S_i = S_1 \times S_2 \times \dots \times S_n$$

entitled the pure game strategy space. For the player $g_i \in G$, there is a utility function:

$$u_i: S \longrightarrow \mathbb{R} \\ s \longmapsto u_i(s)$$

which associates the payoff $u_i(s)$ of player g_i to each profile of pure strategy $s \in S$ (SARTINI et al., 2004).

2.2. Framework of the tragedy of the commons

The tragedy of the commons is a theoretical model used in economic science to address the behavior of a group of individuals sharing common resources (OSTROM, 1990). When there is no regulation on the access to use the common good, individuals acting independently according to their self-interest will cause depletion of the resource through their uncoordinated action.

The concept of the tragedy of the commons became widely divulged after the publication of an article written in the journal *Science* by Garrett Hardin (1968). In his seminal illustration of this concept, Hardin uses the example of land for grazing as a common resource. He debates that each herdsman is willing to maximize their profits. Upon deciding whether he adds an extra cow to the herd, he would take into account two opposing effects: the positive effect is that, when adding one more animal, he increases his gains, increasing the utility of his activities. However, the negative effect is that an additional cow would overgraze the land. However, as it is a common resource, the negative utility would be shared between all herdsmen using that same grazing area.

The herdsman concludes that the most rational decision for him to pursue is to add another cow. However, this rationale is followed by the other herdsmen, leading to the tragedy of commons because it will overgraze the common land.

In this example, self-centered individuals convert the collective benefits of the common land into private benefits. The benefits from adding an extra animal are internalized to their own benefit, while the losses due to overexploitation of land are externalized and borne by the whole group.

3. Results

3.1. Individuals and firms' behaviour: the prisoners' dilemma

One of the most popular examples of the Game Theory is the Prisoner's Dilemma³. This game is an instrument for quantifying social interactions and their outcomes based on mathematical assumptions. It is a game of the social type because choices are analyzed at both levels: the individual's interests (not

² This situation in which an individual choice takes into account other coexisting individual choices is called a game.

³ The prisoner's dilemma was created by Albert Tucker in the fifties as a response to the complications of analyzing certain types of games discussed previously by Merrill Flood and Melvin Dresher (SZABÓ and FATH, 2007).

cooperating) and the groups' interests (cooperation) (COSTA, 2009).

The game consists of two thieves that are arrested by the police after a joint robbery and kept separate in different cells. Nonetheless, the police do not have enough evidence to convict them. First, they were locked together in the same cell before being taken separately for interrogation. They agreed that they would not report on each other (in the game, this is known as cooperation). Then they are interrogated simultaneously (and in different rooms), and the police offer each suspect a deal: he has a chance to refuse to cooperate, claiming he is innocent, and his colleague is the only responsible for the robbery. In the prisoner's dilemma, if a prisoner cooperates, but his partner accuses him of having committed the crime alone, then the cooperating prisoner is sentenced to a longer prison term. Therefore, the reward for cooperation is less than the reward for defecting (BEVER and ROWLETT, 2015). In short, the game is described by the payoff matrix in figure 1. It satisfies the following sequence of inequalities for player 1:

$$(P1) = T > R > P > S$$

Where P stands for "Punishment for mutual defection", T "Temptation to defect", S "Sucker's payoff", and R "Reward for mutual cooperation" (SZABÓ and FATH, 2007).

Figure 1 - The payoff matrix corresponding to the Prisoner’s Dilemma. P means “Punishment for mutual defection”, T “Temptation to defect”, S “Sucker’s payoff”, and R “Reward for mutual cooperation”. Based on Szabó and Fath (2007) and elaborated by authors.

		Prisoner B	
		Cooperate	Defect
Prisoner A	Cooperate	(R, R)	(S, T)
	Defect	(T, S)	(P, P)

An example of illustrative values is represented by figure 2. In this example, if player 2 cooperates, player 1 should defect, because escaping time in prison is better than serving a short time (represented by payoffs 5 and 3 respectively). If player 2 defects, 1 should also refuse to cooperate, because time in prison for a join robbery is shorter than if you are solely responsible (represented by payoffs 1 and 0 respectively). Therefore, either way, 1 should defect. Symmetric reasoning demonstrates that player 2 should defect as well. The game's unique dominant strategy is mutual defection.

Figure 2 - Example of the Prisoner’s Dilemma game with illustrative values. The game is defined by $T > R > P > S$ and $R > (S+T)/2$. Based on Axelrod and Hamilton (1981) and elaborated by authors.

		Player 2	
		Cooperation	Defection
Player 1	Cooperation	<div>R=3</div> <div>Reward for mutual cooperation</div>	<div>S=0</div> <div>Sucker’s payoff</div>
	Defection	<div>T=5</div> <div>Temptation to defect</div>	<div>P=1</div> <div>Punishment for mutual defection</div>

This model represents a situation in which two prisoners have the option to confess or not, but the outcome of the sentences depends crucially on the simultaneous choice of the other (KUHN, 1997). This game is suitable for various real situations with decision-making agents. Thus, it is an important tool for the social sciences (HAMBURGER, 1973).

This game is generally represented as a game for two people, each one having two options. For teaching and illustration, many properties can be more easily understood in a two-person game. However, none of these aspects, neither the amount of players nor the number of options, is a crucial feature of the Prisoners' dilemma, and it may be extrapolated to a group of individuals (HAMBURGER, 1973).

The Prisoners' Dilemma illustrates a paradigmatic example of a conflict between individual and group-centered rationality. A group whose members seek rational self-centered interests may end up getting worse than a group whose members act contrary to rational self-interest (KUHN, 1997). If each individual acts according to his self-interest, they are worse off compared to the situation where they act taking into account the group's interest (HAMBURGER, 1973). And therein lies the dilemma, at least according to the rational choice lenses that refract the world around us.

Mitigating the spread of a contagious virus requires a change in individuals' behaviors, resulting in a game similar to the prisoners' dilemma (ROWLETT and KARLSSON, 2020). Thus, the dilemma can be reinterpreted in the context of the COVID-19 pandemic in Brazil using two average citizens: Mary and Reynolds.

The payoff matrix is defined based on the fact that if Mary and Reynolds cooperate (R), then they are changing their behavior to help mitigate the spread of COVID-19 in Brazil. However, they are also making sacrifices by changing their behavior.

On the other hand, if Mary cooperates while Reynolds refuses, Mary's mitigation efforts decrease Reynolds's chances of contracting COVID-19, and he benefits from Mary's cooperation. Meanwhile, Mary receives the consequences of Reynolds's reckless actions (S). Therefore, Mary is not only restricting her personal freedoms, but she is also at risk of contracting the disease due to Reynolds's recklessness, being the worst scenario possible for Mary (S). Using parallel reasoning, if Mary does not cooperate and Reynolds does cooperate, this would be the best outcome for her (T).

In the case where both refuse to cooperate, then both are at risk of contracting the disease, but neither makes personal sacrifices by changing habits and behavior (P). The situation described also satisfies the payoffs described by:

$$(P_{\text{Mary}}) = T > R > P > S$$

As discussed for the prisoners' dilemma, the sole balancing strategy for the pandemic case is mutual defection. Expanding the reasoning to the whole population of Brazil, the rationale outcome of individuals' decisions will be not complying with social distancing measures.

A similar rationale can be applied to the behavior adopted by firms. The COVID-19 pandemic forced many companies to close, leading to an unprecedented disruption of trade. The decline in economic activity leads to a significant increase in the levels of financial vulnerability, especially among companies in economic activities most affected by the COVID-19 pandemic, such as transportation, and tourism and leisure (BLANCO et. Al, 2020). Retailers have to face many challenges in the short run, ranging from health to business issues, such as cash flow, supply chain, consumer demand, and availability of workforce (DONTU and GUSTAFSSON, 2020). However, if firms decide to cooperate and close their business during the pandemic, they will slow the spread of the virus. This is represented in the prisoner's dilemma by the payoff "R".

In competitive markets, losing to competitors and sectorial rivals can mean the difference between leadership and perpetual struggle (KAUSHIK, 2020). Therefore, if a given firm faithfully complies with the contingency measures and other competitors do not adhere in the same way, then there is a sustained disadvantage that could be plausibly insurmountable (PITAMBER KAUSHIK, 2020). Therefore, the situation where a firm cooperates but the others not is similar to the combination in the prisoner's dilemma where one prisoner is free while the other serves the maximum sentence (S). This is the worst option for a firm. On the other hand, if competitors decide to close their doors and a given firm not, it will benefit immensely with increased demand for itself. This is the best scenario possible of the Prisoner's dilemma (T).

In the context of Brazil, companies fear being left behind in the competition during the pandemic. Moreover, firms are afraid of being unable to close the gaps opened by the pandemic after the ending of the crisis (FAIRLIE, 2020). Thus, even with the adoption of contingency measures that involve the partial closure of stores, firms might choose to open their business anyway and risk being fined (P).

It is worth mentioning that companies are suspicious of each other and do not exchange intimate information with rivals. Like prisoners, they cannot anticipate competitors' decision to keep stores open or adhere to closure. Thus, when one company closes and the others keep functioning, the epidemic

grows in the same way for all and generates the main burden of decreasing demand. However, there is an additional burden for the entrepreneur who chose to close, which is the temporary economic loss that the others tried not to suffer, plus the additional risk of permanently closing the doors (KAUSHIK, 2020).

Given this, payoffs can be represented by the inequality $(P_{\text{firm}}) = T > R > P > S$. The outcome of rational decisions from firms will culminate in mutual defection (P), just as described by the aforementioned cases. Firms will not cooperate with contingency measures, and the pandemic will not be slowed down. Brief, they will be worse off compared to a cooperative decision (R).

3.2.COLLECTIVE BEHAVIOR: THE TRAGEDY OF THE HEALTH COMMONS

The tragedy of the commons applied to public health has already been explored by scholars, such as Yakowitz (2011). Different from the classic example popularized by Hardin where the common resource (collective benefit) is land for grazing, in the case of a contagious disease, the common resource is public health. Therefore, the collective benefit is the population's protection against the effects of the disease.

In the example exposed by Hardin, individuals privately try to appropriate the benefits of common resources, adding more cows to the herd. In the case of a pandemic, individuals privately try to appropriate by benefiting from the prevention to the disease without, however, complying with the precautionary measures.

Yakowitz (2011) exemplified the tragedy of the commons applied to public health with the case of pertussis, also known as whooping cough. Children are the ones at the greatest risk and the best option for the collective would be that every child gets vaccinated. However, some parents opt to not have their children protected. They hope to have both benefits: since every other child is vaccinated, their infant will not probably be exposed to the disease, but they also skip accepted risks⁴ (MOONEY, 2009). The problem is that, once enough parents opt out of the vaccination protection shield, the collective protection falls apart and the common resource (public health) deteriorates. The consequence is that infant mortality from pertussis is increasing because the disease is spreading among infants and adults, who used to be vaccinated but no longer are (EJIGIRI, 2011).

In the case of the Covid-19 pandemic, like the example above, the collective benefit is only achieved if individuals decide to comply with sanitary measures, such as social distancing. This is especially problematic in the case of a pandemic, where public health security cannot be realized individually. Nonetheless, a given individual may opt out not to comply with social distancing measures, avoiding the negative aspects of privation imposed by sanitary measures. Ultimately, this individual would not be subject to changes in behavior and, at the same time, he would still benefit from protection against the SARS-CoV-2 because other individuals are respecting social distancing. Therefore, the individual is privately appropriating the benefits of protection because the detriment of his choice of not cooperating is externalized and shared across the whole group.

Nonetheless, the collective benefit of protection against the new coronavirus will degenerate as soon as more and more individuals realize that they may as well exclude themselves from sanitary measures and still benefit from protection. Ultimately, every individual will opt out until no one respects social distancing measures anymore.

Like the communal vaccination shield, the communal protection against covid-19 is particularly sensitive to opt-outs. As people opt not to cooperate with prophylactic measures, the value of public health protection diminishes abruptly. Brief, collective benefits will not be realized because of self-centered actions.

It is irrefutable that there is no Pareto-optimal equilibrium in addressing the pandemic and there will be always a trade-off between social distancing measures and well-being. However, as a society, we are definitely better off with collective health protection against Covid-19. Therefore, the problem of the tragedy of commons is related to uncoordinated compliance with social distancing measures and this is the case for public intervention. The rationale behind this is that the public sphere, restricting individuals to privately appropriate the benefit of public health forcing them to comply with social distancing measures, avoids deterioration of public health during the pandemic.

4. CONCLUSIONS AND IMPLICATIONS

According to the game theory, particularly the prisoner's dilemma, agents acting at the individual level

⁴ Some people believe that there is a relation between vaccines and the rise in autism rates. As fully contested by the scientific community, such risk does not exist. However, it seems real to those that believe it, and it is taken into account in the decision-making process of the vaccine (Mooney, 2009).

will take self-interest decisions during the COVID-19 pandemic. This will lead to mutual defection in changing their behavior. Likewise, supported by the framework of the tragedy of the commons, individual-centered decisions will cause the collective action to deplete the common good, which is protection against the new coronavirus.

The behavioral analysis conducted in this article using basic and well-established models is in line with the proposition of Skinner of keeping “simplicity in data” (2003):

If we are able to account for the behavior of people in groups without using any new term or presupposing any new process or principle, we shall have revealed a promising simplicity in the data. This does not mean that the social sciences will then inevitably state their generalizations in terms of individual behavior, since another level of description may also be valid and may well be more convenient. (SKINNER, 2003, pp. 326)

Nonetheless, although presenting a limiting application, we believe that the analysis proposed in this paper continues to provide a useful framework for assessing individual and collective behavior in the context of a pandemic.

The Covid-19 pandemic will remain a challenge for an indefinite time, and until the publication of this article, the global situation may have changed. Still, the COVID-19 crisis might be an opportunity to prepare for even more dangerous pandemics that could take place in an increasingly globalized world. We cannot predict the emergence of new dangerous viruses, nor can we fully predict how society will react to a new threat. However, behavioral models can help to understand rational decisions made by individuals when exposed to these situations. The actions described here, based on what was observed during the pandemic, can be interpreted as having a rational character if we assume that the definition of rationality for such individuals is related to the maximization of individual utility.

It is worth mentioning that there are no perfectly defined principles that clarify what is a rational decision and, in pandemics, people adopt different conceptions about which attitudes are rational or not. However, in critical moments such as the COVID-19 pandemic, actions have harmful potential and, therefore, interventions are needed to restore public order. The coordination of individuals' behavior is essential so that the community as a whole can carry out the best choices aimed at overcoming the pandemic and minimizing its impacts.

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Processo de Decisão Individual e Coletiva Durante a Pandemia de Covid-19 no Brasil: Simulações em Teoria dos Jogos e Tragédia dos Comuns

Resumo: Esse artigo tem como objetivo discutir o processo de decisão individual e coletivo durante a pandemia de COVID-19 no Brasil. Para isso, utilizamos modelos teóricos, a saber, teoria dos jogos e tragédia dos comuns, para simular comportamentos durante a pandemia. A análise aponta que, de acordo com a abordagem do “Dilema do prisioneiro”, cidadãos e empresas tendem a não modificarem seu comportamento para cumprirem as medidas de distanciamento social. Consequentemente, sua situação será pior se comparado a uma decisão baseada no bem coletivo. Além disso, o quadro teórico da tragédia dos comuns prevê que indivíduos, tomando decisões centradas em si, optarão por não seguirem as medidas sanitárias. Isso levará a uma deterioração do benefício coletivo, que é a saúde pública. Desse modo, uma intervenção pública é justificável para coordenar o comportamento dos indivíduos uma vez que estarão em melhores condições caso cumpram com as medidas de distanciamento social.

Palavras-chave: covid-19; teoria dos jogos; modelos comportamentais; tragédia dos comuns; escolhas coletivas.