

INDIVIDUAL AND COLLECTIVE BEHAVIORS DURING THE COVID-19 PANDEMIC IN BRAZIL: SIMULATIONS ON ECONOMIC THEORETICAL MODELS

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RESUMO

Esse artigo tem como objetivo discutir qual é o comportamento 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. Conseqüentemente, 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.

ABSTRACT

This paper aims to address the decision-making process of individual and collective behavior during the COVID-19 pandemic in Brazil. Our analysis will use theoretical models in economics,

namely game theory and the tragedy of commons, to simulate individual, firms, and collective behavior in the pandemic in Brazil. According to the approach of the Prisoner's dilemma, citizens, as well as firms, are inclined to defect mutually from changing their behavior. Therefore, they do not 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. It will lead to the depletion of the collective benefit, i.e., public health. Therefore, public intervention is justified to coordinate the behavior of individuals 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.

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 declare SARS-CoV-2 as a 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). Contemporary world history has not witnessed such a massive shift in individual and collective behavior (SENHORAS, 2020a).

Brazil reported its first case at the end of February 2020 (CRODA and GARCIA, 2020). Alike other countries, the diffusion of the new coronavirus significantly impacted human relations, generating broad repercussions (SENHORAS, 2020b).

To address the spread of the pandemic, the government implemented sanitary measures aiming at social distancing. They involved the suspension of in-place teaching and working, shutting down specific commercial activities, 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 thus are not isolated. The importance of such measure lies in the fact

that the country has not adopted a comprehensive testing strategy. Therefore, 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). As it is 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 significant 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? Our analysis will use theoretical models to simulate citizens, firms, and group behavior during this event.

Analysis point that, according to the approach of the Prisoner's dilemma, citizens, as well as firms, are inclined to defect mutually from changing their behavior. Therefore, they do not 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. It will lead to the depletion of the collective benefit, i.e., public health. Therefore, public intervention is justified to coordinate the behavior of individuals 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. This game allegorizes 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.

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).

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

The game theory is ideal for examining rational decision-making strategies in complex environments with several agents (MONTEIRO, 2008). It is a theory that analyzes situations where the outcomes of a player's decision depend 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 $G = \{g_1, g_1, \dots, g_n\}$. Each player $g_i \in G$ has a finite set of options $S_i = \{s_{i1}, s_{i2}, \dots, s_{imi}\}$, called pure strategies of the player g_i ($m_i \geq 2$). A vector $s = (s_{1j1}, s_{2j2}, \dots, s_{njn})$, where s_{ijj} 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:

$$u_i: S \rightarrow \mathbb{R}$$

$$s \mapsto u_i(s)$$

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 sciences 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.

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

The commons' tragedy concept became widely known after Garrett Hardin's article "The Tragedy of the Commons" publication in the journal *Science* (1968). In his seminal example, Hardin illustrates the tragedy of the commons using 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 consider two opposing effects: the positive is that, when adding one more animal, he increases his gains, increasing the utility of his activities. However, the negative aspect 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 interests. The benefits from adding an extra animal are internalized to their own advantage, while the losses due to overexploitation of land are externalized and borne by the whole group.

3. RESULTS

3.1. INDIVIDUALS' AND FIRMS' BEHAVIOR: 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 analysis draws on both levels: the interest of individuals (not cooperating) and the interest of the group (cooperation) (COSTA, 2009).

The game consists of two thieves arrested 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 "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 one responsible for the robbery. If one player cooperates but his partner accuses him of

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).

committing the crime alone, 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 payoff matrix in figure 1 represents the game. 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".

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

Based on Szabó and Fath (2007) and elaborated by authors.

Figure 2 illustrates the game. 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 joint 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 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	R=3 Reward for mutual cooperation	S=0 Sucker's payoff
	Defection	T=5 Temptation to defect	P=1 Punishment for mutual defection

Based on Axelrod and Hamilton (1981) and elaborated by authors.

This model represents a situation in which two prisoners have the alternative to confess or not, but the sentences depend 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 a useful tool for the social sciences (HAMBURGER, 1973).

This game represents two people, each one having two options. For teaching and illustration, a two-person game is easier to understand. However, none of these aspects, neither the amount of players nor the number of options, is a crucial feature of the Prisoners' dilemma, and one may extrapolate analysis 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 than 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.

In order to mitigate the spread of a contagious virus, individuals must change their behavior, 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' chances of contracting COVID-19, and he benefits from Mary's cooperation. Meanwhile, Mary receives the consequences of Reynolds' 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' 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 they are at risk of contracting the disease. However, 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 (DONTHU 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 Brazilian context, 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' decisions 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 $(P_{firm}) = T > R > P > S$. The outcome of rational decisions from firms will culminate in mutual defection (P), just as described. Firms will not cooperate with contingency measures, and the pandemic will not stop spreading. 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 benefit from the prevention of 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. As children face the greatest risk, the best

option for society would be to vaccinate them all. However, some parents choose not to have their children protected. These parents hope to have both benefits: given that most of the kids are vaccinated, they expect that their child will not be exposed to the disease, but they also skip the vaccine 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 respect social distancing. Therefore, the individual privately appropriates 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 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. In brief, the group will not benefit from the collective shield 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 tragedy of commons is related to uncoordinated compliance with social

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).

distancing measures. Thus, it is the case for public intervention. The public sphere, upon forcing individuals to comply with social distancing measures, avoids the 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 will take self-interest decisions during the COVID-19 pandemic. It 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 behavioural analysis in this article used basic and well-established models and it 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)

Although limited, we believe that this analysis continues to provide useful framework for assessing individual and collective behavior in the pandemic context.

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 contagious 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 simulations in this article, also based on observations 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 maximizing individual utility.

It is worth mentioning that there are no perfectly defined principles that clarify what is a rational decision. In pandemics, people adopt different conceptions about which attitudes are reasonable 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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