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# The game theory applied to the Covid-19 pandemic

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## Abstract

The classification of COVID-19 as a pandemic by the World Health Organization (WHO), substantiated a global crisis in public and economic health, exposing failures of governments and markets in terms of the ability to act in a corrective, preventive and, above all, predictive manner, given the appearance of exogenous factors. One of the visible consequences of the pandemic is the polarization between Economy and Health in the countries, creating a competitive environment that resembles a duopoly where each player ends up acting and making their decisions according to what the other does. This article considers this scenario by quantitatively evaluating economic results that are possible to be achieved when in a negotiation essay between 'Economics' and 'Health', using the economic theory of games. The discussion developed points out to the existence of an "optimal strategy" for both the 'Economy' and 'Health' player, capable of maximizing the expected payoff for the population. From the application of the Pareto Equilibrium combined with the Coase Theorem, there is an opportunity to eliminate market and government failures with the achievement of a 'Social Optimum' throughout this and eventual future pandemics.

**Keywords:** COVID-19; WHO; Coase Theorem; Pareto Balance

## 1. Introduction

The world crisis that broke out in December 2019 in China, when the first case of COVID-19 was registered, follows, 'ipsis litteris', the booklet of the so-called "Growth Dilemma", announced by [1]. Such a dilemma alerts us that it is possible to have ample sufficiency and, for not realizing such condition, to surpass the optimum 'prosperity point', passing to a stage of counter productivity [2].

The idea of lasting prosperity has a high cost because they promote that welfare is related to the consumption of goods and services, establishing a modern and globalized language of "I have, therefore: I am!" [3]. The cost of prosperity can be measured precisely in times of visceral fears, of incredible inequalities, of structural chaos personified by COVID-19 [4] and [5].

"Quickly, the sensation of imminent collapse causes that before something about 16 million times smaller than us, we start to behave like hunted animals" [6], in an escape position from our predator. The panic dictatorship, despite the usual attempts at unity and collaboration, historically, as suggested by [7] and [8], flows into conflicts that, if not solved, tend to aggravate situations generating more panic, in a kind of vicious cycle.

In the specific case of the COVID-19 pandemic, one of the most striking conflicts has been between 'Health' and 'Economy' that, from mere members of "Governments", were promoted to supreme rulers of nations starting to dictate directions. The actions suggested by the World Health Organization (WHO) regarding social isolation have usually

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encountered explicit or veiled resistance in the face of countries' economic issues. According [9] there is a strong dependence between companies and families in a circular flow involving a cycle of goods, services and income, which is fed back by spending on consumption and investments.

Thus, when families are isolated and, for reasons of health preservation, the workforce is contained, goods, services and income are reduced and, consequently, expenses and investments follow the same trajectory. The result is the economy entering into recession, which in turn impacts the public finances of rich and poor countries, causing higher social costs, lower tax collection, cuts in public services and, among other externalities, creating more burden on Health. Formerly allied, Economy and Health, when perceiving themselves in the middle of the "hunting season", they start to behave as players who make strategic decisions considering the decision and responses of each other.

Considering this, the paper quantitatively assesses the possible economic results to be achieved when in a negotiation essay between Economics and Health, using the economic theory of games. The discussion developed shows the existence of an optimal strategy for both the Economy and Health, capable of maximizing the expected payoff for the population. Consorting Pareto's Equilibrium to the Coase Theorem results in an economic trial with alternating attribution of "right of decision" on public order seeking a strategic solution obtained through a cooperative economic game between the two mentioned actors.

This strategic solution through a cooperative economic game between these actors shows that the joint use of the Economic Game Theory and Coase's Theorem makes it possible to achieve a socially optimal economic result as negotiations between the parties occur, if and only if, transaction costs are not prohibitive.

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## 2. Existence of an optimal strategy

In view of the inexistence, until the date of conclusion of this paper, of a vaccine against COVID-19, most countries have chosen to adopt enforcement measures when it comes to social isolation. This measure, in addition to being suggested by the WHO, has gaining strong support as the deaths related to COVID-19 were reported in the international press. However, in spite of the serious health crisis established worldwide, it is clear that another crisis, of considerable magnitude, was also gaining strength [10]. If health systems in the overwhelming majority of countries were not prepared to fight COVID-19, the world economy in the process of reorganization came to be threatened and the markets quickly exposed their shaky knees. After moments of perplexity regarding the consequences of the disease caused by COVID-19, market forces began to question social isolation as an optimal intertemporal solution, emphatically remembering that the effects of prioritizing Health over the Economy, have the potential to cause social costs even greater than those of the disease itself [11].

In the light of the 'Game Theory', this perception refers to the possibility of cooperation between 'Health' and 'Economy', obviously respecting the effects of COVID-19, but seeking joint strategic planning and through a balanced agreement, called 'optimal Pareto solution' [12]. In applying such a tool, neither Health nor Economy can raise their level of payoff without harming each other.

A negotiation between 'Health' and 'Economy', based on the identification and agreement on the existence of externalities1 can be obtained considering the existence of a point of common agreement between the declared players. According to [13], gains with the internalization of externalities can overcome damages, as announced in Coase's Theorem, being therefore fundamental in the present case, only the definition of which of the participants 'Health' or 'Economy', must have the right of primacy in decisions over the scope of social isolation.

According to [6], mathematically the negotiated solution that reaches the socially optimal level depends, among other conditions, on information symmetry, in which:

$$BMgLP = P - CMg \qquad \text{(Equation 1)}$$

1 The term used does not intend under any circumstances to diminish or suggest less importance to human life, but only to serve the purpose of the simulation of economic results proposed in this article.

At the optimum point, we get the equality:

$$BMgLP = CMgE$$ (Equation 2)

From Equation 1 and 2 we obtain:

$$P = CMg + CMgE = CMgS$$ (Equation 3)

Where in the above equation: BMgLP is the Net Private Marginal Benefit, P the price of goods or services basket, CMg the Marginal Cost, CMgE the External Marginal Cost and, CMgS the Social Marginal Cost.

When considering that both 'Health' and 'Economics' consider, in this case, that under their direction, the social benefits are greater than the social costs, a government action is needed to induce a negotiated solution.

## 3. Scenario analysis and Coase's Theorem application

In order to obtain a qualitative assessment of Coase's Theorem application in the negotiations involving the Management of 'Health' and 'Economy', it is necessary to identify and analyze the risks to the population, in the event of reaching a negotiated solution [14].

According to [15] "Coase Theorem is a legal and economic theory developed by economist Ronald Coase that affirms that where there are complete competitive markets with no transactions costs, an efficient set of inputs and outputs to and from production-optimal distribution will be selected, regardless of how property rights are divided. Further, the Coase Theorem asserts that if conflict arises over property rights under these assumptions, then parties will tend to settle on the efficient set of inputs and output"

Coase introduced the concept of transaction costs to explain the nature and limits of firms discussing the 'Problem of Social Cost' [16], which suggests that well- defined property rights could overcome the problems of externalities (Coase theorem). Additionally, Coase's transaction costs approach is currently influential in modern organizational economics, where it was reintroduced by Oliver E. Williamson [13].

Considering the evident dichotomy established between 'Health' and 'Economy', given the COVID-19 pandemic, it is possible to carry out a scenario analysis by means of a SWOT matrix, establishing as external factors, those involving two or more nations and those involving only national issues, as shown in Table 1.

**Table 1** COVID-19 Pandemic Scenario Analysis

|  | **Favourable issues** | **Unfavourable issues** |
|---|---|---|
| External factor | Respect for general human rights principles | Increase in the number of deaths and complications of COVID-19 |
|  | Promotion of cooperation between countries in order to share experiences and research in the fight against the new coronavirus | Shortage of distribution chains for products made in China |
|  | Increase in investments in health services | Decrease in the world economy as a result of negative reactions from the financial market, in addition to the negative impacts on global production and consumption chains |
|  | Awakening to additional personal and collective hygiene habits | Disagreements between leaders of nations that may delay humanitarian aid and / or validation of eventual vaccines |
|  | Export opportunities for certain countries due to factors such as favorable exchange rates | Import difficulties for certain countries due to problems such as unfavorable exchange rates |
|  | Improvement of environmental quality in all its aspects |  |
| Internal factor | Respect for general human rights principles | Increase in the number of deaths and complications of COVID-19 |
|  | Promotion of cooperation between 'institutional powers' of the same nation | Health Services collapse |

| | Review of public policies, in general, with an emphasis on supporting the poorest and tax incentives for private initiative | Internal power disputes between authorities, in view of the moment of intrinsic fragility of Governments and public institutions |
|---|---|---|
| | Review of legislation, in general, aiming at maintaining jobs and household income | Increase in the number of unemployed people. |
| | Increase in investments in health services | Closing companies and increasing bankruptcies |
| | | Reduction of tax collection by the State. |
| | Improvement of environmental quality in all its aspects | Risk of recession with expressive and rapid increase in public debt |
| | Awakening to additional personal and collective hygiene habits | Threats to freedom of expression and citizens' mobility right |

Based on the Coase Theorem, associated with Pareto Equilibrium [13], the scenario described above can then be considered as a "cooperative game" with associated values (payoffs) to a result that can bring benefits to players if they are willing to negotiate. In this case, as [6] suggests, the strategy that will maximize the benefits between 'Health' (player 1) and 'Economy' (player 2), necessarily goes through rigorous and detailed joint planning. In other words: the transaction costs between 'Health' and 'Economy' must be zero, the state of competition between the players must be perfect and the information must be symmetrical and transparent between the parties.

Based on Coase Theorem [6], indicates that the establishment of the property right is what determines the action beginning of the agreement between the parties with a view to reaching a stage of equilibrium and, consequently, socially desirable. In the present case, it is the establishment of the right to the primacy of the decision between a lockdown (total confinement of the population in their homes) and the general and unrestricted liberation of the population to carry out their routine activities.

Therefore, on the side of the player 'Health', it is assumed that his extreme ideal is the decision to lockdown, intending the welfare of the population, however such a "move" implies economic losses for the same population. Otherwise, the player 'Economy', has his ideal in the decision for "normal life", also intending the welfare of the population, emphasizing that in this case such a "move" implies losses of life for part of the population.

The fundamental basis of this "game" is that the board is circumscribed to the territorial limits of a given nation and that the government of that nation is the one who defines the decision primacy right.

Thus, the marginal external cost of the player 'Economy' is an increasing function [17] related to the externalities caused by the state of lockdown imposed on the citizens of a nation. From the 'Health' player, the net private marginal benefit is a decreasing function [17] and has the marginal benefit of the last person in total confinement equal to zero.

For simulation purposes, the following marginal costs/benefits must be considered:

$CMgE_{Economy} = a \times Q$       (Equation 4)

$BMgLP_{Health} = b - a \times Q$      (Equation 5)

Where,

$CMgE_{Economy}$ = Player 'Economy' external marginal cost in \$/person in lockdown

$BMgLP_{Health}$ =     Player 'Health' private net marginal benefit in \$/person in lockdown

Q = Quantity of people in lockdown

a = Generic slope coefficient

b = Generic slope coefficient

Figure 1 shows the possibilities of existing trading scenarios and the optimal number of persons in lockdown. The ordinate indicates the lockdown costs in $/person in lockdown and the abscissa the number Q of persons in lockdown.
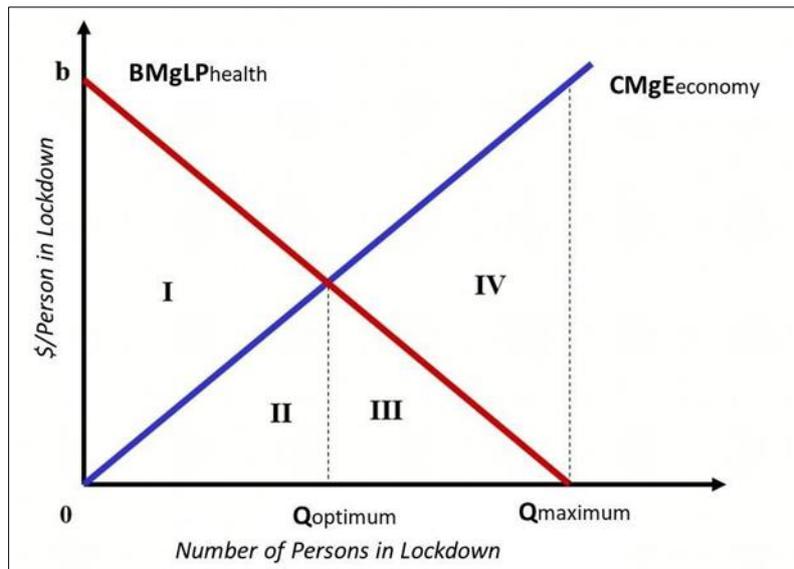


**Figure 1** Illustration of negotiation scenarios between 'Health' and 'Economy' players

In Figure 1, considering any time interval, and based on Equations 5 and 6, we get: $Q_1 = 0$ people at lockdown; $Q_2 = Q_{max}$, maximum people at lockdown and $Q_S$ = Maximum number of people at lockdown.

The analysis of the situation described in Figure 1 suggests that, in the event that the primacy decision right is granted to player 'Health', the initial interest of this will be to keep the maximum number of people in lockdown, as this leads to the Maximum Total Benefit.

However, the Maximum Total Benefit of the player 'Health' leads to the Maximum Total Cost for the player 'Economy', the latter being responsible, in this case, to seek conciliation with player 'Health' - holder of primacy right to decide on the amount of the population that should or should not remain in lockdown - to propose a negotiation.

Considering that the equilibrium point obtained in the proposed paper is $Q_S = Q_{optimum}$ persons in lockdown, the player 'Economy' will be willing to financially

compensate the player 'Health' by paying at least an amount equivalent to the area III of the Figure up to the equivalent of the sum of areas III + IV, in the form of allocation of future tax collections, for example, in order to guarantee the reduction of people in the $Q_2$ lockdown to $Q_S$. The existence of trading in these terms promotes the achievement of Pareto´s Optimal Point.

On the other hand, in a scenario in which the right of primacy to decide on the amount of the population that should or should not remain in lockdown is given to the player 'Economy'; the initial interest of this player will be not allow any intervention in people's daily lives, as this leads to a Total External Cost equal to zero. However, in this case the Total Benefit of the player 'Health' will be zero. In this case, it is the player 'Health' who will look for player 'Economy' - now holder of the right of primacy of the decision - to propose a negotiation.

Considering that the equilibrium point obtained is $Q_S = Q_{optimum}$ persons in lockdown, player 'Health' will be willing to compensate in some way translated into currency to 'Economy', between the equivalent of area II, up to the equivalent of the sum areas I + II, in order to guarantee an increase in the number of people in lockdown, from $Q_1$ to $Q_S$. This will guarantee player 'Health' an ideal capacity to deal with the pandemic.

The players' willingness to accept a deal stems from the fact that it is possible, for the holder of the primacy right over the lockdown decision, to receive compensation greater than or equal to their total costs, caused by the operations of the other player.

## 4. Final considerations

The theoretical results obtained show that the solution negotiated between the parties, regardless of the player to whom the Government of a nation grants the right of primacy in deciding the scope of social isolation, will be socially optimal. Obviously, in practice, such negotiation involves the value of existence and, therefore, it goes far from triviality because it involves a real possibility of death, either by COVID-19, or by adverse reactions caused by preventive measures linked to it (suicides, heart attacks etc.).

Thus, it becomes necessary not only to satisfy Pareto's optimal axiom, but also to ensure that the negotiation process is developed in a democratic and swift manner, minimizing bureaucracies that can transform the many negotiation efforts into late and irrelevant returns for society.

As limitations of the proposed model, we have to consider that other actors, such as: 'Environment', 'Work', 'Science' and 'Technology', when realizing the possibility of indemnity occurring, may claim some gain and cause the negotiation to be prolonged or just doesn't happen. Other limitations are related to possible difficulties in approving the negotiation result by the legislative and judicial powers.

In the Brazilian and in the eventual case of other Latin American countries, it is worth mentioning that the existence of "electoral interests" must be considered in relation to the increase in transaction costs.

The authors chose to limit themselves to the discussion of a theoretical economic model, without the respective empirical validation, due to the importance, timeliness and volatility of the theme, once to carry out the practical validation of the model could take longer and lose, eventually, actuality.

Finally, the authors clarify that the theoretical essay presented above points to the feasibility of applying the negotiation between the parties, which can only occur through the perception, determination and government actions of countries in applying such a model, disclosing the results achieved, to provide opportunities for future and necessary adjustments.

## 5. Conclusion

As shown, in the case of confronting COVID-19, admitting the possibility of negotiation between Economy and Health, there is an optimal solution capable of preserving lives at lower costs for society.

## Compliance with ethical standards

*Disclosure of conflict of interest*

The author declares no conflict of interest.

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