# Application of Game Theory on People Dealing with Masks

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**ABSTRACT**

For the outbreak of COVID-19, the easiest and most effective method of prevention is to wear a mask. However, many citizens remain strongly opposed to wearing masks. Therefore, it is very important to understand people's psychology about wearing masks. This study was conducted to understand the behaviour of the public from the perspective of the dominant strategy and Nash equilibrium by building a game model. It can be found that people are more inclined to not wear masks. Hence, government measures are required, included both making people aware of the shame and taking strong measures.

***Keywords:*** *Game theory, prisoner's dilemma, COVID-19, masks, regulations*

## 1. INTRODUCTION

Started from the end of 2019, the pandemic which would affect the whole world came. With advice from an authoritative medical expert in China [1], people began to wear masks to protect. Masks became scarce resources for a time in China due to closed factories in the spring festival that is the most important festival for Chinese people. Meanwhile, citizens might feel breaths are taken away with face masks. Masks were still taken off even though unruly individuals understood masks directly determines transmission routes of viruses. Under this critical challenge, this paper aims to build up game theory matrixes to explain why selfish people still do not use masks when they know risks to health and subsequently to give probable solutions to control the spread of the virus. It is expected that this research can raise public awareness of wearing masks to reduce the possibility of being infected.

## 2. ECONOMIC IMPACT OF THE PANDEMIC

The world's economies had been buffeted by the pandemic. In general, all three main economies, Asia, Europe, and United States are affected. China, as the second-largest economy appears the first contraction over decades, but its GDP was expected to grow by 8.4% in 2021[2]. But the situation in other countries does not seem optimistic, India's GDP was estimated to a decline of over 7% in the first quarter in 2021[3]. The economy of the European Union decreased by 7.4 percent in 2020. Spain and the United Kingdom are the most severely affected economies, given GDP decline by 12.4% and 10.3% respectively[4]. The gross domestic product of France could decrease from 11.4 to 14.1% in 2020. The largest decrease hits the country before the end of 2020 with renewed lock-downs[5]. Real U.S. GDP increased by 33.4 percent in the third quarter of 2020, after two decreases in the first quarter and the second quarter due to The Fed's move[6]. All countries around the world have experienced economic recessions or slowdowns.

## 3. A BRIEF DESCRIPTION OF GAME THEORY

Game theory is one of the standard analytical tools in economics. The game theory model used in this paper is the Prisoner's Dilemma. The most classic Prisoner's Dilemma is a scenario built by two people. For each of these two people, he or she has two choices, to confess or not to confess. Each person's different choices determine the number of years he or she will be sentenced and the other person's and are interconnected with each other. Dominant Strategy is the best choice of competitive strategy for one's side regardless of how the other opponent reacts to the competition. For example, in this case, the dominant strategy for B is to confess whether A confesses or not because 8 is less than 20 and 1 is less than 3. Also, whether B confesses or not, A's dominant strategy is to confess, because 8 is less than 20 and 1 is less than 3. A combination is defined as a Nash

equilibrium if the strategy chosen by anyone participant is optimal given that the strategies of all other participants are determined. If person A decides to confess, there will be no benefit for person B to move away from 8 years to 20 years. When person B confesses, there is no benefit for person A to change a strategy once again. 08/08 is a Nash equilibrium because it is a place that no benefit for either player to change a strategy given the strategy the other person has played. For square 03/03, given that person B not confesses, person A benefits of moving away from 3 years to 1 year. It is also true for person B, and he or she also move away from this. Therefore, 03/03 is not a Nash equilibrium. For box 01/20, no benefit for person B to move away, but person A prefers to move away, so 01/20 is not a Nash equilibrium. Likewise, the box 20/01 is not a Nash equilibrium.

## 4. MODELLING OF GAME THEORY

To set up the matrix, two players are involved in this game. Each person has two main conditions, healthy and unhealthy, and they also could be split into two situations, with and without a mask. In total, there will be four different situations, healthy with and without a mask, unhealthy with a mask, and unhealthy without a mask. This paper gives 10 points for the satisfaction of healthy without a mask, 8 points for the satisfaction of healthy with a mask, 5 points for the satisfaction of unhealthy without a mask, and 3 points for the satisfaction of unhealthy with a mask. There are several reasons for how this paper marks these behaviours. The scores for two cases with masks are lower than another two cases without masks because of the uncomfortable and unpleasant feelings with masks. What's more, unhealthy people have a lower score than healthy people due to afflictive symptoms. Finally, this paper also points out that the satisfaction of a healthy person without a mask will change to 5 points, because of the infection from an unhealthy person without a mask.

| | Person A Confess | | Person A Not Confess | |
|---|---|---|---|---|
| **Person B Confess** | 8 years | 8 years | 1 years | 20 years |
| **Person B Not Confess** | 20 years | 1 years | 3 years | 3 years |

**Figure 1** Fundamental Game Model: Prisoner's Dilemma

## 5. ANALYSIS BASED ON THE MODEL

When a healthy person A, facing a healthy person B, the dominant strategy for person A is not wearing a mask because the satisfaction gained by not wearing a mask is greater, compared 10 with 8. Similarly, when a healthy person B meets a healthy person A, the dominant strategy is still to obtain greater satisfaction by not wearing a mask. The Nash equilibrium is at 10/10. Neither would bother to change their strategy to reduce satisfaction. When a healthy person A meets an unhealthy person B, there is no dominant strategy for A because A is more satisfied without a mask when B has a mask, compared 10 with 8. But A is less satisfied without a mask when B does not have a mask, compared 5 with 8. And for B, the dominant strategy is not to wear a mask, because whatever the case of A, satisfaction 5 is greater than satisfaction 3. By the same token, a healthy person B, facing an unhealthy person A, has no dominant strategy. At this point, for A,

the dominant strategy is not to wear a mask, because no matter how B chooses, satisfaction 5 is also greater than satisfaction 3. Under these two circumstances, the Nash equilibrium of the first is at 05/08, and the Nash equilibrium of the second is at 08/05. The reasons are that neither player will change their strategies at these two points, and if we compare the players' satisfaction horizontally and vertically, we will find that the satisfaction will only be equal to or less than the satisfaction at the Nash equilibrium. Finally, when two unhealthy people are together, if we compare the satisfaction of wearing a mask and not wearing a mask, we find that A's dominant strategy is not wearing a mask and B's dominant strategy is also not wearing a mask, both because satisfaction 5 will be greater than satisfaction 3. The Nash equilibrium point will be at 05/05, at which point no one will choose to change strategy.

| | | A | | | |
|---|---|---|---|---|---|
| | | Healthy with a mask | Healthy without a mask | Unhealthy with a mask | Unhealthy without a mask |
| B | Healthy with a mask | 08/08 | 08/10 | 08/03 | 08/05 |
| | Healthy without a mask | 10/08 | 10/10 | 10/03 | 05/05 |
| | Unhealthy with a mask | 03/08 | 03/10 | 03/03 | 03/05 |
| | Unhealthy without a mask | 05/08 | 05/05 | 05/03 | 05/05 |
| | | | | | |
| | Healthy with a mask (10) | | | | |
| | Healthy with a mask (8) | | | | |
| | Unhealthy without a mask (5) | | | | |
| | Unhealthy with a mask (3) | | | | |

**Figure 2** Mask Game Model

# 6. DOMINANT STRATEGY AND NASH EQUILIBRIUM ANALYSIS

This paper focuses on the dominant strategy and the Nash equilibrium to analyse the situation of people wearing masks. The dominant strategy mainly describes the player's choice when he or she is independent of each other [7]. In the four cases mentioned above, for A and B, either there is no dominant strategy or the dominant strategy is not to wear a mask. It is easy to see that people prefer not to wear a mask when they make their choices independently. Besides, the Nash equilibrium represents the situation we most expect to occur when players act in their own self-interest [8].

In this model, four Nash equilibrium are 10/10, 05/08, 08/05 and 05/05.10/10 and 05/05 reflect both players tend to not wear a mask when their health conditions are same. 05/08 and 08/05 illustrate that if one person is infected, the other person will choose to wear a mask.

# 7. SUGGESTIONS FOR THE GOVERNMENT AND INDIVIDUALS

From the above, it is clear that people prefer not to wear masks, so relying on people's self-awareness alone is unreliable. The government must play a good role. Here, this paper will mention one of the national cultural patterns of Japan - the culture of shame [9]. This helps the authorities to understand the public psychology and formulate policies. People in this culture are very concerned about what others say, think, and talk about. Therefore, their behaviour will be regulated by many external social factors and standard norms. The government should tell people about the dangers of not wearing a mask. It is actually an individual choice to be infected by not wearing a mask yourself, but endangering the health of others is not just a personal business. When people around look at the person who is not wearing a mask with hate-filled eyes, that person will have a sense of psychological guilt and will most likely put on a mask in the next time he or she goes out. But this method is a psychological one and may not always work well.

The government should also take some strong measures, for example, some cities were locked down and public transport was suspended. Regional government rebuked citizens who didn't follow the rules with echoing loudspeakers. Besides, 14,000 health checkpoints were established at main transport hubs across the country and an effective national tracing system was set up [10]. With all these measures, China controls the pandemic rapidly and effectively. For citizens, although the satisfaction gained from not wearing a mask is greater than the satisfaction of wearing one, we can't just think about ourselves, but also about the people around us. People tend not to wear masks, or wear masks if they know the other person is infected, but all of this is based on the premise of knowing the other person's health condition. But in reality, we have no way to know if the people around us are infected. Therefore, the only way to ensure that you will not be infected is to wear a mask at all times.

# 8. CONCLUSION

In conclusion, people tend to not wear masks due to the difference in satisfaction. Also, people will choose to put on a mask after they know that the other person is infected. In response to the problems encountered, this paper advises governments and people. But this paper only discusses the game situation within two people. In reality, there is a high probability that multiple people will encounter each other, rather than two. In the future, new game models can be built to reflect a more realistic situation, which should lead to more detailed conclusions.

## AUTHORS' CONTRIBUTIONS

This paper is independently completed by the author.

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