

Cooperation on Protecting Public Health in the COVID-19 Pandemic based on Game Model

Yingxue Mi¹, Mengqi Sun² and Zixuan Wang^{3,*}

¹Department of Political Economy, King's College London, London, WC2B 4BG, U.K.

²Department of Economics, Wilfrid Laurier University, N2J 2Y2 Waterloo, Ontario, Canada

³School of Economics, Huazhong University of Science and Technology, Wuhan, Hubei, 430074, China

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Abstract: This article discusses the application of the public goods game (PGG) under the ongoing crisis of public health. We applied the traditional PGG to a case study of individuals' choice to contribute to the provision of public health because of COVID-19 and then introduced theory of three behavioral types. That is, a third type of behavior exists aside from cooperating and defecting – called 'conforming', which describes one's imitation of the majority's actions. In the empirical analysis, we chose to use the daily number of vaccinated people reported by national public health organizations in the UK as a valid and reliable indicator for differentiating individual behaviors. As illustrated by the data for British vaccination uptake between January and July 2021, conformists tended to observe what the whole population has chosen at early stages of the vaccinating process, before making their own decisions. The last portion provided possible explanations behind the behavior of conformists, thus demonstrating the inadequacy of the traditional PGG in this context, as the act of defecting does not always maximize individual utility in fact. Hence, we conclude that the mass's behavior during the COVID-19 crisis is more complex than the case described in the PGG. For instance, cultural backgrounds and social infrastructures also play a critical role in the decision-making of individuals responding to the provision problem of public health in different societies.

1 INTRODUCTION

The COVID-19 pandemic has been challenging public health systems in both developed and developing countries since 2020. With a potentially great risk of underproviding public health, people are expected to cooperate and contribute to the provision, whereas some may become defectors enjoying benefits brought by others' efforts. Through a case study of UK people's response to the ongoing epidemic, this essay argues that the traditional public goods game (PGG) model where players are required to select from two strategies exclusively does not fit the real case, due to the existence of conformists who tend to imitate cooperation before making ultimate decisions.

The first section below is separated into two parts: Firstly, we review the theoretical model of PGG by interpreting the primary features of a public good and

how public health can be regarded as a type of public goods in the pandemic context; Then, we explain why an extension theory to the classic PGG (Wu, Li, Zhang, Cressman and Tao, 2014) fits empirical cases more perfectly, after specifying how the concepts in a PGG are applied to the pandemic. Next, we focus on analyzing how empirical investigation supports the existence of the conforming type of behavior as well as potential reasons behind the conformists' behavior in this context.

2 LITERATURE REVIEW

Traditional economic theories were developed based on the assumption that individual persons are rational and self-interested. In other words, people are assumed to act solely in pursuit of utility/payoff maximization.¹ This assumption has been applied to

¹ Self-interests usually refer to money, but could be happiness, pleasure, and others.

many branches of economics, and here we chose to analyze one of the famous models in game theory, namely, the public goods game (PGG). However, the rationality assumption was not backed up with empirical investigation before being applied to answering economic questions. That said, this essay aims to argue that the PGG fails to well interpret how people in the UK have behaved during the COVID-19 pandemic.

2.1 The Public Goods Game

In game theory, public goods have two defining characteristics: nonexcludability and nonrivalry. Nonexcludability means that the cost of stopping nonpayers from benefiting the good or service is prohibitive. In other words, once a good or service is provided for one person, no one - e.g., those who do not contribute to paying for it - can be prevented from consuming it. The second aspect of public goods is non-rivalrous consumption. That is, one person's consumption of a public good does not diminish the amount of it available for consumption by other people (Cowen, 2008). National defense is often used as an example of public goods as it meets the two components. Firstly, a citizen who has not contributed to paying for it cannot be prevented from enjoying the protection from national security threats. Secondly, the fact that other citizens are also getting the benefits does not mean a reduction in one individual's benefits from national defense (Dixit, Skeath, Reiley, 2015).

Table 1: Payoff Matrix for The Public Goods Game.

		Player 2	
		Cooperate	Defect
Player 1	Cooperate	a, a	c, d
	Defect	d, c	b, b

Note: The PGG has a prerequisite: the following inequality $d > a > b > c$ has to be satisfied.

Game theorists proposed a theoretical model, called the public goods game which involves multiple players making decisions simultaneously. Table 1 illustrates how the basic PGG framework runs. Everyone in this game has two strategies, namely, either to cooperate and contribute to the provision of the public good or to defect at the cost of others' efforts. A payoff with a fixed value is assigned to each player's strategy given what his/her opponents have chosen to do. However, the fact that players are assumed to be rational and self-interested

determines that they will always choose the strategy which yields a higher payoff given their fellows' action. As a result, individuals in the PGG have incentives to defect at the cost of other players' contribution to the public good. Such a problem of free riding indicates a Pareto inefficient outcome – i.e., it is possible to make everyone better off without making anyone else worse off, have they chosen to cooperate and contribute to the public good.

2.2 Public Health as the Public Good in COVID-19 Pandemic Case

Since the coronavirus pandemic broke out in 2020, how people in the UK have responded to the public health crisis can be reframed in the PGG scenario. To put it another way, we believe that the epidemic case has all the three elements required in a PGG experiment. Firstly, there are multiple players, namely, a defined number of UK citizens across all demographic features. Moreover, public health can be regarded as a type of public goods. According to Merriam-Webster, the definition of public health is 'the art and science dealing with the protection and improvement of community health by organized community effort and including preventive medicine and sanitary and social science'. An example is herd immunity which is an essential goal to handle pandemics usually achieved by vaccination. However, one may argue that some goods or services of public health do not fit nonexcludability and nonrivalry of public goods, such as sanitation and clean water. To avoid any vagueness caused by this, we add two more features proposed by Dees (Dees, 2018) to the definition of public goods in this context. In other words, public health constitutes four elements: (i) it is a good; (ii) it is nonexcludable and nonrivalrous; (iii) the public benefits from the good via collective effort; and (iv) it is important enough to warrant collective effort. Or in the words of Dees, public health can be justified as a normative public good.

2.3 Theory of Three Behavioral Types

Compared to the feasibility of the PGG, a hypothesis which divides participants' behavior into three types –namely, defecting, conforming, and cooperating – can better explain how people behaved in real cases (e.g., Wu et al.). Firstly, players with the cooperating type of behavior contribute the most to the public good. Meanwhile, their contribution rises once they find that their donations are below or as the same as the group average. Furthermore, conforming is used

to describe the participants that are only willing to donate the average amount to the public good. When they realized that they contribute more than the average level, they would reduce the amount of contribution in later rounds of the game; vice versa. Put another way, players with the conforming type of behavior tend to observe the strategies of the vast majority and then mimic their action, hence a

conformist is also called an imitator (Cartwright and Patel, 2010). Another type of behavior is defecting which refers to players who always contribute from zero to less than the average amount. An essential condition for the existence of defection is that the majority chooses to contribute so that only a small part can free ride on others' efforts. The table below demonstrates the three types of behavior in the PGG.

Table 2: Description of Three Behavioral Types in Experimental Games.

Types of Behaviour	Description
Cooperating	Participants always contribute more than the group average to the provision of the public good.
Conforming	Participants are only willing to contribute the average contribution of all individual players who have already acted.
Defecting	Participants always donate less than the group average to the provision of the public good, or even do not make contributions.

Source: Wu et al. (2014)

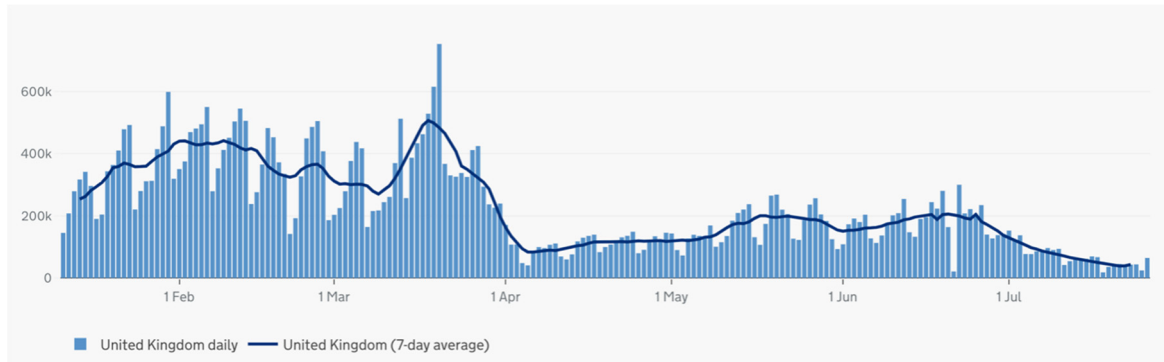
Under the ongoing pandemic, the strategy to cooperate in the PGG corresponds to collective effort on protecting public health. More specifically, cooperating and contributing to public health is primarily represented by the willingness to make contributions that protect all the human beings from the infectious disease – e.g., wearing face masks, obeying social distancing and other effective measures suggested by the UK government and public health organizations to decrease the potential risk of infection. On the other hand, defection is illustrated by those who firmly disagree with protecting public health. For instance, police forces have reported a rise in large illegal lockdown parties since last year, while the UK government has been imposing the ‘rule of 6’ that allowed up to six individuals or two households to meet in person during the pandemic (The United Kingdom Government Website, 2021).

This essay utilizes COVID-19 vaccination rate of getting at least one dose between January and July 2021 as the exclusive indicator for one’s contribution to public health based on three considerations. Firstly, vaccines are deemed as one of the most effective means of slowing down the spread of the virus, compared to other pharmaceutical methods. Secondly, getting vaccine is voluntary in the UK, which ensures treating vaccination rate as a reliable and valid indicator of cooperation. Another factor is because of a high accessibility of data collected by national public health organizations. Hence, we believe that vaccination rate is a justified indicator

for cooperation in this context given the limited availability to other indicators.

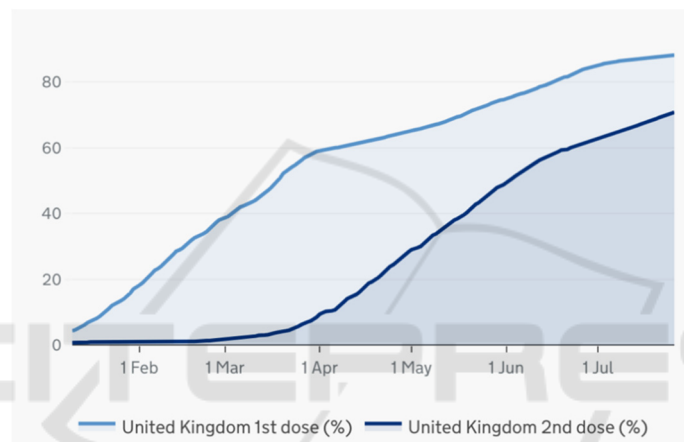
3 EMPIRICAL ANALYSIS

The feasibility of three behavioral types being applied to the public health crisis is justified by the fact that the conceptions are comprehensively explained in such a context. Firstly, cooperating suggests one’s high willingness to contribute to public health more than the population average. Moreover, conformists tend to wait for others’ action so as to maintain a group average contribution, whilst defectors have no attempt to follow any rules and regulations for protecting public health. For instance, the latter refuses to wear face masks in public places or to receive COVID-19 vaccines that primarily benefit themselves. Hence, this group of people act as free riders that enjoy the benefits from public health protections made by other contributors. This section focuses on how empirical investigation supports the existence of three behavioral types as well as potential reasons behind the conformists’ behavior in the pandemic context.



Source: The UK Government Official Website 2021.

Figure 1: The number of people who have received a first dose of COVID-19 vaccination (daily reported).



Source: ibid.

Figure 2: UK Vaccination Uptake (daily reported).

3.1 Case Study of UK Vaccination Rate in 2021

The two figures above demonstrate how the theory of three behavioral types applies to the pandemic context in the UK. As shown by Figure 1, the daily number of UK first-dose recipients tends to be steadily high during the first three months of 2021, fluctuating around 400,000. This group of people are those who played cooperation and contribution by voluntarily taking the first dose of COVID-19 vaccines before the start of April. In other words, they chose to contribute more than the mass average to public health protections. By April 6, first-dose vaccination uptake has reached 60% among the UK population, while the number of people receiving a first dose started to fall significantly around late March. Such a significant decline in the daily number of first time COVID-19 vaccinators has two implications. On the one hand, the earliest group of

first-dose recipients was people with high willingness to cooperate on public health protections. The data for this crowd experienced a downward trend in late March though still above zero, which means cooperators have gradually finished their first-dose vaccination by early April. On the other hand, this is followed by those conformists who started to get vaccination in early April. As taking COVID-19 vaccines has practically become the choice of the majority at that moment, conformists that always tend to maintain an average contribution appeared to observe what the majority has selected before imitating. In contrast to both cooperating and conforming types of players, how people defected is not reflected in the number of daily reported first-dose recipients as defectors would never do so.

3.2 Conforming Behavior in Getting Vaccination

In the context of the pandemic, one possible reason why conformists imitated the majority's strategies is out of safety considerations given unknown risk of injecting a new vaccine. The UK government gave first authorization to COVID-19 vaccines of the Pfizer-BioNTech and the Oxford-AstraZeneca in December 2020 – and to Moderna's in a later month – as data showed very high levels of protection against symptomatic infections with COVID-19 in clinical trials (The United Kingdom Government Website, 2021). However, slightly adverse reactions and fatal side-effects of vaccination still occur at a relatively high possibility among different age groups. For instance, blood clotting that exposes young healthy adults to danger might be the most severe after-effect of injecting the AstraZeneca vaccine (The United Kingdom Government Website, 2021). As an increasing number of people – especially those that conformists know – have been vaccinated (at least the sample size is large enough for conformists to be convinced) without seeing a wide range of side effects in the population, conformists might rest assured to get the first dose of vaccine. Therefore, conformists carefully chose not to vaccinate first when the COVID-19 vaccines were officially approved and put into use, due to any unknown risks of getting fatal or lifelong side effects.

The second crucial factor for the conforming type of behavior is because of opportunity costs. In the long run, the failure of effectively controlling the spread of coronavirus brings higher social and economic costs than the foregoing of conformists' short-term self-interests – i.e., than to cooperate and contribute to public health. If most people choose to insist on their freedom of travelling or socializing instead of complying with epidemic prevention measures, the spread will become increasingly faster, and thornier it will be to control. Meanwhile, the COVID-19 pandemic has been hitting the global economy very hard. According to the June 2020 Global Economic Prospects, the baseline forecast envisions a 5.2% contraction in global GDP in the year of 2020, by using market exchange rate weights. This indicates the deepest global economic downturn in decades. Moreover, these deep recessions triggered by the ongoing pandemic are predicted to 'leave lasting scars through lower investment, an erosion of human capital through lost work and schooling, and fragmentation of global trade and supply linkages' (World bank group, 2020). The decline in consumer's demand under national

lockdowns and government's priority to public health over economic growth have made small businesses that could not afford operational costs closed down and also hit middle to large businesses hard as well. This, in turn, has caused layoffs and thus rising unemployment. From this point of view, conformists realize that the earlier the effective control of the epidemic, the lower the cost of recovery, and large-scale vaccination may be the most effective pharmaceutical method to protect public health.

4 CONCLUSION

By analyzing the British public's choice of vaccinating against COVID-19, we have shown that the rationality assumption in the PGG does not match the reality. First, the definition of public goods in this article has four dimensions: (i) it is a good; (ii) it is non-excludable & non-rivalrous; (iii) the public can benefit from the collective effort of the supply contributed to it; and (iv) the justification of the collective effort is important enough. According to its definition, public health meets these four characteristics. In the PGG, players are allowed to choose between two strategies exclusively, namely, contributing or not contributing to the provision of the good. In the COVID-19 case, the corresponding two strategies are cooperation on public health protection - such as complying with measures effectively preventing from the spread - and defection, such as any violation against epidemic prevention. According to traditional economic theory, a rational player should never choose to contribute as not contributing guarantees a higher payoff/utility than contribution, no matter what other people's choices are. However, such an assumption cannot be warranted since there are more than two types of behavior in real cases. A third type of behavior exists, called conforming/imitating.

Through the analysis of UK COVID-19 vaccination in past several months, we found that a group of people chose to wait until most people received the first dose, instead of doing so in the early stage when the vaccine was just approved for use. Two possible explanations are provided: (i) conformists were worrying about the unknown risks from the new vaccine. Clinical trials show data for reference that cannot speak for each individual's situation; (ii) and the longer the pandemic, the more serious the economic downturns will become. More workers, especially those in the retail and other service industries, will face unemployment. From

social and economic perspective, conformist ultimately chose to vaccinate.

This essay conducts a qualitative study, by using the daily number of people receiving the first dose of COVID vaccines in Britain, to demonstrate the shortcomings of the traditional PGG. Further research on this topic could develop from the following two perspectives. First, more statistical support for different types of indicators for cooperation, especially experiment conducted on the change in attitudes of conformists, are desired to improve the validity of our argument. In addition, researchers can explore the situation in other countries in depth. Under different social infrastructures, the reasons that play an important role in the transformation of the subject's attitude may be different. For example, citizens of most Asian countries have relatively higher moral pressure from the environment, which means mere observation of one's behavior may not help distinguish between cooperating and conforming. Also, restraints made by governments and authorities on citizens will lead to further cooperation. Hence, some may treat these as key variables that possibly affect how people respond to public health protections in different settings.

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