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Research Report

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Towards a Stable Nash Equilibrium of the Game of Global Covid Lockdown

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Abstract

Various attempts have been made to reveal the impact of corona virus on the global economy through interdisciplinary approaches. The ultimate logic behind the strategies adopted by leaders of various economies regarding the first level policy response of lockdown and the and the end level solution through low cost responsive vaccine with zero negative externalities has raised a self-sustainable crux which raise the question of why the world is not yet reached "Global Nash Equilibrium" in which all countries may reach a covid fear free economy. In this context the present is attempt to fill this gap by developing a game theory based model. Keeping the present market structure for the vaccine and it is also predicted that demand curve for the vaccine even if it is in competitive price level become flat.

Key Words: Non cooperative Games, Nash Equilibrium, Global Equilibrium, lockdown Economics, Demand Curve for Covid Vaccine.

JEL Classifications: C72, C73, D03, D43, D81, F05, E03,

Prelude and the Purpose

It is the gift of god that human only can make decision and choose among the alternatives available. Economic theories classified such decision making under three types vice decision making in deterministic, probabilities and uncertainty situations which can be studied using the game theory approach which makes an implication of everything is game and every activity of human being can be conceptualised as the strategy towards achieving a payoff or benefit.

Lock down is identified as one of the preliminary measure to prevent the spread of corona virus among the public as a result it is widely implemented by various countries. This strategy was worked with massive acceptance over the globe up to certain limit and becomes not acceptable by the public across countries due to the limited vanished resources hold by the public to meet the daily needs.

Assume the situation as a theory of game in with two players of government and public, it is shortlisted about four strategies. The government has two strategies vice adopting the lockdown and withdrawing it and similarly the public has also have the two strategies to accepting to the lockdown measures, follow the pandemic rules or not accepting the lockdown rules and become the victim of the virus or spread it to others.

In a two by two game type of situation there is a possibility of Nash equilibrium in which both players (Government and Public) can reach a benefitable point and keep it stable and can be expendable to all economies of the world and can form a global Nash equilibrium. There are very few attempts are published in the academic connecting the theory of game and its implication to form such global Nash equilibrium. This brief work is an attempt to fill this gap in research by exploring the possibilities of global Nash equilibrium within the realist conditions.

Objectives:

1. To review the game theory and identify the new areas of the applications
2. To discover the possibility of global stable Nash equilibrium
3. To explore and predict the demand for the covid-19 vaccine worldwide
4. To suggest the policy measures that mitigate the coordination failure

With this objectives the present work uses the following methods.

Methods:

The concept of Nash equilibrium is used to verify the economic decision making by the two players public and the government. Since the data on the payoff is not available quantitatively the qualitative information are used to construct the payoff matrix with some realistic assumptions. The analysis of the dynamics of the players is done using the diagrammatic approach and the conclusion are arrived separately for the present collusive oligopoly and predicted the future with perfectly complete market structure and verified how the global stable Nash equilibrium can be achieved without the lockdown policies globally with the enquiry of possibility of multiple equilibria globally (Martin J. Osborne. V, 2002).

Assumptions:

1. There are two in this game. Government on the one hand and the public on the other.
2. Each has two strategies in their hands wise adopting the lockdown and the withdrawing it; accepting the lockdown and rejecting it oppositely.
3. Both players are rationale
4. Governments choose the strategy which result to maximise the public utility.
5. Individual try maximise the private utility.
6. Information is equally available and accessible by everyone.
7. The vaccine is not invented /available to all or accepted globally.

8. The pandemic virus will spread through the humans and human activities more than that of all other mode. It means if we are less mobile the virus also will migrate more and vis versa.
9. Individual who are affected by corona virus will create the private cost of the recovery and also incur a considerable amount of social cost of monitoring and backup treatments etc.

With this assumption the conceptual setting for the present attempt can be given as the found in (Jenny Duffy 2015).

Long run, Stable and Global Nash Equilibrium

Nash equilibrium is a situation where both players find a strategy which gives relatively maximum payoff. In order to make it clear the following example can be used in the conventional way presented by the payoff matrix format (Roger B. Myerson 1999 & Kouser wise 2020).

Pay off matrix of the game:

	Adopting the Lockdown(Government)	Withdrawing the Lockdown(Government)
Accepting the lockdown rules	<div style="display: flex; justify-content: space-between;"> 1 All are Safe </div> <div style="display: flex; justify-content: space-between;"> Safe and No Spread 2 </div>	<div style="display: flex; justify-content: space-between;"> Safe for All 2 </div> <div style="display: flex; justify-content: space-between;"> low Marginal cost Individual Safe and No Spread </div>
Rejecting the lockdown rules	<div style="display: flex; justify-content: space-between;"> Difficulty to Control 3 </div> <div style="display: flex; justify-content: space-between;"> Social Cost Virus Attack and Spread </div>	<div style="display: flex; justify-content: space-between;"> 4 Increase of Virus/ More MSC </div> <div style="display: flex; justify-content: space-between;"> Virus Attack And Spread to Everyone </div>

In the above conventional form of payoff matrix the end result of the game played in between the public and government is given. For the sake of easy interpretation of the

matrix the four alternative outputs with eight results are given with numbers of 1 to 4 in the boxes. Let us take the first box which expresses that if government adopts the lockdown and public respects and obeys the lockdown rules, government will get the payoff of all safe, which can reduce the social marginal cost of the pandemic and the financial resources can be diverted towards innovative research and development of vaccine and can solve the issue shortly as soon as possible. At the same time, public also can be safe with the minimum spread of virus for the limited time period of lockdown.

The second payoff given by the box numbered 2, in which government withdraws the lockdown rules but public still follows most of it and rarely violates some of the rules like mobility in search and or job activities but with precautions of self-safety and keeping the safety of others in mind, (for example always using the mask while out and keeping sanitizers handy etc) will be safe for the individuals in the country and can be safe for all and will result in the low marginal social cost.

Similarly, the box three reveals the payoff for the government and the public while the government uses the strategy of lockdown and the public rejects it. This is the realistic situation which arises when the public spent all its savings during the lockdown and the government's inability (of course it may not be possible in the long run) to offer any relief and rehabilitation financially to all its population. This results in the increasing chance of the virus attack with the risk of violating the lockdown rules while going to work and other unavoidable activities without proper safety measures for self and the society. The government also has to face severe consequences resulting from the increasing social marginal cost and the uncontrolled spread will create the tension among the policy makers to take in efficient policy solutions. This is not the efficient solution both individually and socially.

The last outcome in the matrix table numbered 4 reflects the strategy of withdrawal of lockdown rules by the government and the strategy of not following any of the lockdown rules with the assumption that the pandemic is solved. In this action the

both players are supporting for the spread of virus resulting to the higher social cost of the government and the increasing possibility of the attack and (or) (both) the spread virus to everyone which is also not desirable for the private and socially. Based on the work of (Charles A. Holt and Alvin E. Roth 2014) the multiple equilibrium possibilities can be traced as below.

This is the real world example of a two by two game with multiple equilibrium. The box numbered 1 and 2 are desirable for both players. But the payoff given in the box 2 is relatively more desirable than it is found in the box 1. It means when the lock down is implemented it can be acceptable by the public in short run and efficient only for the short run up to which the individual can survive with the saving that they already have. After which when earning individuals come forward to scarify their health to save their family by going to any income generation activities they will move from box one to box 3 in which both players will get worse off. So the box one is not desirable to both players since it works only in short run and the lock down becomes a need again as in the case of a few countries discussed by (BI India Insider 2020).

But in case of the box numbered 2 it is efficient for both players where both can get maximum benefit. It means even after the lock down measures are relaxed if public still follow some of its rules it will be the best solution to both players in the game in which the government social cost of the pandemic measures will reduce and the chance of spread and the attack of the virus also can be minimised even in the long run. So this is the optimal solution to the game.

Implementing the lock down and accepting the lock down measures will work in the short run but can be a stable one. Implementation of lock down by the governments and accepting, changing the culture following the lockdown rules by the public for ever would be the long run Nash equilibrium in this game.

Now the question is how long this equilibrium will survive at what boundary. To answer this question first we have to look into the geographies of the economies and

and the nature of demand and supply of the vaccine in the short run and in the long run.

Global Nash Equilibrium

Keeping all the assumptions given above if the players are converted to the two economies than the same interpretation will lead to reach the compelling conclusion that regardless of what the other players adopt a country to follow its own lockdown rules up to the availability of vaccine at low cost would be the perfect solution both for the people living within the country as well as people living globally. If one country violates and or releases the lockdown rules while the nearby countries till severely affected it is still a signal that any point of time the spread of virus will again increase in various unknown ways. That's why the second waves of the virus has created the lockdown situation again in many countries like Germany, England, and the United States of America (W.H.O 2020).

Time limitation of this Equilibrium

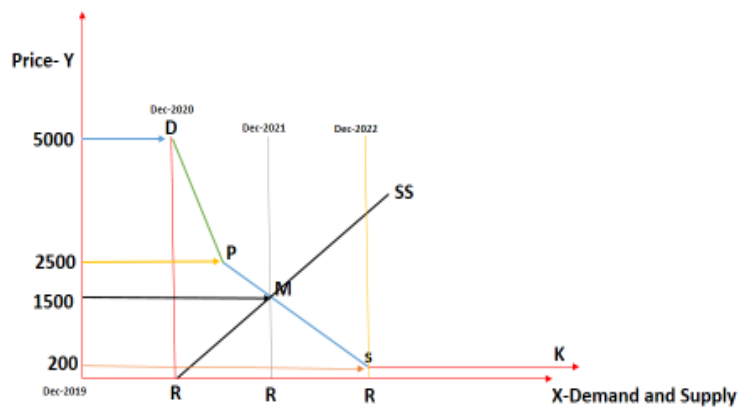
It is known to everyone that the lockdown is a preventive entry level measure only and not the permanent solution to it. The ultimate solution is to invent a vaccine that can prevent the chance or to cure it. To understand the question of how long the equilibrium would be an efficient solution with lockdown we need to look into the demand and supply curve of the vaccine across the various time period and can identify the duration of long run global Nash equilibrium.

Based on the ongoing trend of the developing a vaccine with globally acceptable standard at low cost we further assumes that the time minimum time required for the initial vaccine availability after series of test trails is 1 year and the same amount of time required by the policy makers around the globe make reach out the vaccine to every citizen. It is also assumes rationally that the initially a few firms will come up with a successful vaccine and create a duopoly or oligopoly market supply with or without collusion with monopoly price or will charge a joint profit maximising price

at which only the affluent can access to it. Later it would become a competitive market which can be accessible by anyone at reasonable minimum cost.

On the other hand the demand for the vaccine in the long run would be a dynamic one with various form of elasticity's. First without any knowledge of the virus people will come forward to offer any amount to price to make themself safe while the vaccines are not available in the markets. So initially the demand for the vaccine would be a vertical line parallel to the Y axis meaning that whatever the price the world is in need of certain quantity of vaccine. This is shown in the figure on the point the year up to January 2020 to December 2020.

Long run Nash Equilibrium with Demand and Supply of Vaccine



The above illustration can be used to explore the vaccine demand and supply chain relationship with the lockdown economy and trace the point upto which the long run Nash equilibrium can persist and what will happen afterwards. In this figure the demand and supply of the vaccine is taken in horizontal axis while the price of it taken in the vertical axis. As per the assumption of the one year minimum time required to develop the vaccine the demand for the vaccine is expressed by the vertical line RD highlighting the perfectly en elastic demand for the vaccine from the starting of the pandemic from origin measured by December 2019 to December 2020 in which the

price is at very (5000 dollars per dose per time assumed); due to lack of supply of vaccine (WHO 2020) and fear of the virus attack people will come forward to offer any price even higher than this level (Ella Wills -2020).

In the second stage after one years of research into the vaccine and test trails some of the producers come up with the vaccine and supply will start from the point of R rather than from the origin. The upward sloping line from left to right named SS is the supply curve of the vaccine after one year of pandemic and the demand curve for the vaccine is now has changed from its initial shape of vertical RD into DPMS with a kinked point of P representing the kinked demand faced by oligopolistic. It is also true that initially the supply of the vaccine is possible only by internationally competent and low cost or dominant firms which fix the maximising profit (in both with price and output cartel or without collusion)(Business Today 2020) . The scarcity of availability of medicine only in few part of the world and the unavailability of the same in other parts of the world will create a doubt about the vaccine and its efficiency among the public which stimulate the public to not take the vaccine at the first stage itself and wait for the repeated confirmation of the reliability of the vaccine globally. In addition to the one year knowledge of the virus and its impact across various modes will further postpone the decision to take the vaccine even if it is available at relatively cheaper cost as found in the figure at 2500 dollars. It is the reason why the demand curve for the vaccine is with a kinked portion at the point of P. From the point D to P it has the shape of less elastic revealing that some of risk taking individuals come forward and take the vaccine. From the point of P to S with more elastic demand revealing that the supply should meet both demand (Economic times 2020). The equilibrium of the market can be said to have at the point M at which the market supply would become competitive compare to the oligopolistic market found at P. now the price of the vaccine has further reduced as a result of the entry of additional firms in the industry. Still if the global demand is not met with abnormal profit enjoyed by a few multinational firms who are in vaccine production will attract the new local firm everywhere around the globe with objective to share the profit and

increase the output. If this is happened after the equilibrium point of M by December 2021 (as per the assumption that one year time required to reach all the individual in the world). This is the not the stable equilibrium as it has the locked down situation. After the time of December 2021 if the supply is still increase by the perfectly competitive firms assuming the availability of abnormal profit it will father leads to fall in price which everyone can access with proved quality. After the releasing the lockdown globally due to the availability of medicine will increase the supply and caused to the fall in price cut up to a minimum 200 dollars which is called the Nash equilibrium in the long run. After this even if the lockdown is released it will the price will never fall below this production cost price and will stable at the rate of 200 dollar due to the nature of infinite elastic demand of vaccine.

It is worthwhile to note that the Nash equilibrium formed at the intersection supply and demand is not stable whereas the stable equilibrium is found where the supply is more than that of the demand. It suggest that in case of the health issue like this pandemic the global equilibrium can be found where the supplystocks of the vaccines are reasonably higher than that of the demand for it.

Core Finding and Concussions

1. The second box in the payoff matrix can be the one which can be the collusion to this non cooperative game.
2. There may be multiple unstable equilibrium in the short run in any economy and globe among which any one can be stable equilibrium in the long run.
3. There must be a stable equilibrium with and without the lock down between which the second one is would be preferable.
4. It will take up to December 2022 to reach the global stable Nash equilibrium in the world.

Scope for further research

The present attempt is made to highlight the possibility of the stable Nash equilibrium of the world by taking the case as an activity of game between the governments and

the public. Similarly the role of asymmetric information and its externality impact on the covid management globally can also be studied as a separate model. The studies on the causes of market failure through the coordination models towards this pandemic may also be highlighted on these issues in a different way and can be verified with similar work to reach a compelling conclusion of whether the present attempt is reliable or not.

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