Fighting infectious disease: the game that occurs between developing and developed nations

ISCI 330 – Game Theory

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Infectious diseases are prevalent throughout the world. What varies is how well the progression and transmission of diseases are controlled in developed countries as compared with developing countries. The severity of infectious diseases in developed countries is not as great due to differences in prevention and available treatment options such as vaccines and drugs. All the same, this level of control has been gained through combating the pathogens which cause disease quite aggressively; now that there is a level of control that has been achieved in developed countries, controlling such diseases in developing countries must also be examined.

There are various interactions that occur at various levels between many different players when considering combating infectious diseases; some of the players include the pathogens which cause disease, the individuals affected, large corporations, and countries. Infectious diseases are a major problem in the world, especially in developing countries, where approximately 95% of deaths from infectious diseases occur (Folch *et al.,* 2003). Furthermore, only a handful of diseases, almost all of which are either preventable or treatable, cause the majority of these deaths (90%); the most common of these diseases are HIV/AIDS, tuberculosis and malaria (World Health Organization, 1999). Unfortunately, although there are methods to control the spread of disease, and ways to reduce or even eliminate the effects of these diseases, developing countries too often lack the resources to be able to use such measures.

Assuming that the more prevalent infectious diseases can be tightly controlled through measures such as vaccines, antibiotics and other drugs, a problem arises as to who should take

part in the fight against pathogens to control and reduce the prevalence of infectious diseases. This is where Game Theory can contribute; the problem of who should contribute and how much, to the fight against pathogens in an effort to control and reduce the severity of infectious diseases can be examined by modeling the situation as a game.

The game being played is one where the players are developing countries playing against rich countries, or large corporations (or even both). Developing countries would be more than willing to contribute what resources they have, but they cannot do it on their own; rich countries and/or large corporations will have to eventually step up and contribute to the fight. However, it does not simply involve asking rich countries to contribute resources such as drugs, manpower, or money, but rather also involves complex interactions: the decision whether to contribute, and how much to contribute, is affected by many other 'smaller' games, the results of which will ultimately affect the decision made by countries or large corporations to help combat infectious disease. This paper will examine the game that exists between developing countries and rich countries, as well as some other games that influence this interaction in the fight to control the spread of infectious disease. According to Folch *et al.* (2003), a non-zero-sum game approach is necessary for the interaction between developing countries and developed countries – the players of the game – to be beneficial.

Having identified the players of the game, we need to consider how these players interact, what kind of game, or games, these interactions result in, and what the payoffs for each are. The game arises because developing countries are not in a position where they, alone, can effectively combat infectious diseases within their borders, as they simply do not have the resources to do

so. These countries will need aid from wealthy nations, or even large corporations, to begin

fighting disease. In spite of this need, we do not see enough aid being given to developing

countries, although the persistence of infectious disease affects not only the countries where they

are prevalent, but also the rest of the world (Folch *et al*., 2003; Folland *et al*., 1997, cited by

Smith *et al.*, 2004). Folch *et al.* (2003) believe that developing countries have been predisposed

to losing because the game is perceived as being zero-sum, where the payoffs for each player are

exactly opposite to each other; they do not suggest any specific game to model the interactions,

but rather consider non-zero-sum games in general, and only discuss possible benefits of playing

a non-zero-sum game, which will be considered later. I disagree with their opinion that

developing countries have been predisposed to losing because the game is seen as being zero-

sum; the game does not necessarily have to be zero-sum, but rather could be one of many non-

zero-sum games, with the resulting payoffs being lower for developing countries than developed

countries which would create the illusion of a zero sum game where developing countries

consistently lose. In fact, the game played between countries seems to be one of Prisoner's

Dilemma, and a closer look at the interactions between each player and the actions available will

show this to be possible.

In Prisoner's Dilemma, there are two actions available to each player: to cooperate or

defect. Maximal payoff is received when one player defects and the other cooperates; however it

is the cooperator who is punished in such an interaction. With the actual players, developing

countries can choose to cooperate or defect. Except in extreme cases, they will choose to

cooperate, and do what they can to help reduce the prevalence and severity of infectious

diseases. Developed countries or large corporations also have the same action choices.

However, they do not often choose to cooperate, but rather will defect. This interaction of the cooperating developing countries and defecting developed countries is one which yields the former the least gain and the latter the most. This can be seen in attempts to control infectious diseases in the pas and present: In the fight against smallpox, many poor countries tried to eliminate the virus on their own, but failed due to the lack of technical and managerial expertise needed (Fenner *et al.* 1988, cited by Barrett 2004). In the current fight against AIDS, many rich countries have been failing to keep their promises regarding contribution of resources (Anonymous, 2004). There appears to be many incidences of developed countries promising to provide some degree of assistance, but then failing to follow through; if this has occurred repeatedly, it will make it difficult for a developing country to show trust towards the other player(s). From this, if a poor country does not trust a developed country to follow through, they may choose to defect and not make any commitment or any plans to combat a particular disease. When both players defect, this is the Nash equilibrium of the game, which is not an optimal solution in any situation; why the players would prefer to defect needs to be examined, and another solution found, which may involve having to change the game.

Developing countries would lose far more if they cooperated and began allocating funds and other resources to fighting a particular infectious disease, relying on assistance from developed countries, which then defect than if they simply defected from the beginning. On their own, developing countries do not have sufficient resources to combat infectious disease, and if they allocate even a portion of their resources and are left hanging, they lose the resources used, and they are no closer to reducing the prevalence of disease. Developed countries may choose to defect because they do not see any benefit to cooperating – within their own border,

they are already able to control the diseases which are of extreme severity in the developing world, thus helping the developing world can only lead to a perceived loss of resources (money, manpower, drugs, or vaccines). Furthermore, there is no perceived loss in choosing to defect; at first glance, for developed countries, it does not seem that the prevalence of infectious disease in the developing world would be of any consequence to them. While there may not be a "direct" influence, there is some effect: Wilkinson (1992) argues that inequalities in income results in a burden on the poor, which affects the competitiveness of societies, which, in turn, affects the global marketplace. In addition, since the world is becoming more and more integrated everyday, the world should be concerned with the health of all people, especially since health is fundamental to the growth and development of society. Thus we can see there are some losses in choosing to defect, but these losses still do not seem to directly affect developed countries to any great degree. In addition, when considering why developed countries defect, the game taking place among them should also be considered.

There is not only the one game between developing and developed countries. There is another game among different developed countries; the outcomes of this interaction affect what happens in the larger game. Assuming that aid given to a developing country will come from a number of sources (developed countries or large corporations), there must be some degree of cooperation among those potentially contributing resources. However, whenever there are at least two contributors, each is tempted to do less than their share and thus become a free-rider, which can result in no cooperation in this game, eventually leading to a choice of "defect" in the game played against developing countries. Rich countries may be tempted to not cooperate with other countries, or large corporations, to help developing countries, because they cannot see a

benefit. However, there can be benefits (Folch *et al.,* 2003) to cooperating with other rich

countries in order to help the developing world.

First, it must be pointed out that it seems that aid is no longer given for humanitarian

reasons alone; there are other reasons to be considered: Gershon (2000) states that an

improvement in the health of the world is important for "economic reasons and political

stability", and Dollar and Levin (2006) have found that the need, in terms of poverty level, social

indicators, and income, of the recipient country should be a factor in allocations; that is to say,

donor countries are becoming increasingly selective when it comes to deciding the 'who' and

'how much' of aid. In addition, the donor country, or countries, ideally would prefer to receive

some benefits in return for their contribution

There are various potential benefits for developed countries when they cooperate; among

these benefits are: the creation of a "safer global village" (Lederberg *et al,*. 1992, cited in Folch

et al., 2003), an increase in economic trading – high income countries are affected by trade

because of infection in developing countries – and establishing bridges of trust and confidence

with the developing countries (Folch *et al.*, 2003). So there are some benefits to cooperating, but

is it enough to ensure that both players cooperate? The problem remains that each player prefers

to defect; however, there may be different conditions where this problem is of inconsequence.

There are two ways to consider this problem: Prisoner's Dilemma as it is, involves no

communication or information about each player's actions, but if communication were allowed,

there might be greater incidence of cooperation. Alternatively, what might be needed is a

different game in which the payoffs, when both players cooperate, exceed the payoffs when one player defects and the other cooperates.

According to Brosig (2002), cooperative behavior in Prisoner's Dilemma occurs when players attempt to maximize the "joint payoff" as opposed to trying to maximize their own profit; in a game of Prisoner's Dilemma, with communication between players, defectors were less likely to exploit the cooperators. This implies that with communication between developing and developed countries, the situation of the former can be improved, as both players decide to cooperate more than they defect. While players might choose to cooperate more frequently if there is communication between them, there still remains the fact that the Nash equilibrium and the dominant strategy for each player to defect is still present. More than just communication between the players is necessary; a wholly different game might be needed.

The coordination game is one in which the payoffs are at a maximum when both players cooperate. There are two Nash equilibria: either both players cooperate (also the pareto-optimal outcome) or both defect. Because the pareto-optimal outcome is also a Nash equilibrium, we would expect to see both players choosing to cooperate most of the time. Cassar (2007) showed that in a small world network (which has the same properties as human networks among societies), the payoff-dominant equilibrium in the coordination game was reached relatively quickly, and that there was more cooperation in the coordination game when compared to Prisoner's Dilemma. The coordination game seems to be an ideal game to model the interactions being discussed here. However, more important is that it actually will be an accurate representation of the actual game; thus in order to 'convert' the Prisoner's Dilemma game played

by developing and developed countries into a coordination game, the payoffs for cooperating must be high enough.

For developing countries, there is no doubt that the benefits, and payoffs, for cooperating are high. However, for developed countries, it is not as clear. What needs to be done is to convert the possible benefits into real numbers so as to be able to compare payoffs, from specific strategies used in playing one round of the game. This is difficult to do, as different countries would most likely assign different values to benefits, in addition to the fact that converting the "amount" of benefit a country receives for cooperating, into numbers is very subjective, even if a scale is used. However, this would be a useful way to compare the two games – prisoner's dilemma and coordination – and to compare these games with the actual interactions that go on between countries, to see how accurate the model is, in terms of what strategies countries use, how effective they are and the actual outcome of such interactions.

The interaction between developed and developing countries has been examined to determine the kind of game being played between these players, which is also influenced by other games. The existence of a game in which developing countries lose and developed countries win without being zero-sum does not agree with the point of view presented by Folch *et al.* (2003), but it is possible to have a loser and winner without having a zero-sum game. The game here seems to be one of Prisoner's Dilemma, with both players choosing to play the Nash equilibrium strategy, but with a change in payoffs, the game can be changed into one of coordination, which would result in more socially desirable outcomes. While the way in which different countries interact has been modeled as a game, it must be remembered that in the end,

health and trying to treat and control diseases is not a game, but rather is a real problem that

faces the world today.

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