THE CORONA VACCINATION DILEMMA

BY **SERVAAS HOUBEN**

Servaas Houben takes a new look the classical prisoner's dilemma and an application to COVID-19 vaccination

Although the benefits of vaccination for a society as a whole are obvious, a non-negligible part of mostly young and healthy people will refuse this protection again COVID-19. In game theory, the prisoner's dilemma provides individual decision makers with a similar problem: choosing an optimizing strategy for individual players does not result in an optimal outcome for society as a whole. Game theory can also explain the current refusal of individuals to get vaccinated and show the impact of incentives.

SERVAAS HOUBEN is actuarial manager IFRS 4 and IFRS 17 at Ergo Belgium.

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PRISONER'S DILEMMA REVISITED

The prisoner's dilemma is one of the most famous examples of Game Theory. In this game, two prisoners (Abi and Ben) are suspected committing a crime. The prisoners can either remain silent (S), or confess (C) and betray the other prisoner. The police does not have sufficient evidence to prosecute either of them on the principal charge without a confession from either prisoner, however there is sufficient evidence to convict them on a lesser charge. Therefore, the prisoners are offered an incentive by the police in the form of a reduction in their sentence if they confess. Abi is not allowed to communicate with Ben throughout.

Let's suppose the payouts for the prisoners are as follows:

- Benefit of confessing is +1 for the reduction in penalty
- When neither confesses, there is a small penalty of -1 for the lesser charge
- When there is sufficient proof (the other prisoner chooses Silence) there is a large penalty of -10 for the principal charge
- If they both confess then the each of them are penalised -9.

TABLE 1: ORIGINAL PRISONERS DILEMMA

		Ben	
		Silence	Confession
Abi	Silence	(-1, -1)	(-10, 0)
	Confession	(0, -10)	(-9, -9)

Looking at the payoff matrix in Table 1 it is clear the best option for both prisoners is to remain silent (top left). In this case each of them receives a small penalty of -1 and the total negative benefit for the both of them is -2. However, when looking at the optimizing choice for each individual one can see that it is always beneficial to choose confession (C):

- Case 1, the other person stays silent: choosing S receives -1, while choosing C receives 0, hence C is the better option;
- Case 2, other prisoner also confesses: option S receives -10, while option C receives -9, hence option C is the better option.

Therefore rational players will choose their optimizing strategy to confess, and the result will be the right bottom option with a total negative benefit of -18, worse than the total of -2 if they had both chosen to cooperate and stay silent.

PRISONER'S DILEMMA IN COVID-19 CONTEXT – 1 PERSON

The example above in the 2-person game can also be used for the choice for vaccination (V) or refusal (R). For an individual however the game needs to be adjusted slightly: instead of having a game with 2 persons, there is now a game between:

- the individual (I), and
- the rest of the society (S).

We assume the following payouts:

- benefit for getting the vaccine is -1 (because some people suffer vaccination side effects);
- benefit of no lockdown is 0;
- however, lockdown costs are severe at -10;
- lockdown occurs when most of Society chooses Refusal; and
- importantly, the choice of a single individual cannot result in lockdown regardless.

The game then looks as follows:

TABLE 2: PRISONER DILEMMA
COVID-19 dilemma – individual versus society

		Society (S)	
		Vaccine	Refusal
Individual (I)	Vaccine	(-1, -1)	(-11, -10)
	Refusal	(0, -1)	(-10, -10)

The game is still the same from the individual perspective in the original prisoner's dilemma: the better option for I is to play R as it is the higher payout in each of the scenarios. However, the choice of S is independent of the choice of I. The choice of a single individual (person I) does not have a material effect on society as whole: no lockdown, evening curfew, or closure of schools occurs when only a single person decides not to take the vaccine. Hence

the payouts to S will not be impacted by the choice of I, and choosing V is best for S independent of the choice if I.

This example shows that when a single individual decides not to get the vaccine, this does not negatively affect the payout to society as the impact of the individual's choice on the outcome of the game is immaterial.

PRISONER'S DILEMMA IN COVID-19 CONTEXT – GROUPS

Now suppose that instead of a single person, an entire substantial group (G), say 50% of the population, refuse the vaccine. This alters the game as a bigger group will have a material effect on the outcome for the rest of society (S). The game is now as follows:

TABLE 3: PRISONERS DILEMMA
COVID-19 dilemma – group versus society

		Society (S)	
		Vaccine	Refusal
Group (G)	Vaccine	(-1, -1)	(-6, -5)
	Refusal	(-5, -6)	(-10, -10)

As G has now a material impact on S, when G decides to play R this will now have an effect for the entire society implying there is a higher chance (50%) of lockdown.

This example shows that when a group decides not to get the vaccine, this does negatively affect the payout to society as the impact of the groups' choice on the outcome of the game is material.

THE INDIVIDUAL VS GROUP PARADOX

The discussion above shows that society can end up with in a worse equilibrium (no-one taking the vaccine) if it lets individuals decide themselves on whether to take the vaccine or not. Clearly one individual by herself does not impact the society as a whole. The optimizing strategy for an individual person is thus not to take the vaccine (R):

- The individual by herself will not impact the possibility of lockdown
- By not taking the vaccine, the individual avoids the drawbacks of taken the vaccine and saves 1.

However when a substantial part of society decides to play this strategy then the outcome of society as a whole worsens: in Table 3 when all individuals in group G decide not to take the vaccine (R) (based on their individual preference in Table 2) the best possible response from S is it play V to limit the impact on society resulting in an overall loss of -11 (left bottom), however this is a worse outcome than the one in the left top corner of -2. How can we induce individual people in a free society to make the right choice for society instead?

Conclusion – use incentives in a free society to get to the optimal equilibrium

As in a free society there is no option of compulsory vaccination, and it is up to the individual to make the vaccination decision, incentives have to be provided to make the choice for option V more attractive (additional benefit of 2 when choosing option V) so that the original Table 2 now changes as follows:

TABLE 4: PRISONERS DILEMMA
COVID-19 dilemma – Individual vs. society with incentives

		Choice S	
		Vaccine	Refusal
Choice I	Vaccine	(+1, +1)	(-9, -10)
	Refusal	(0, +1)	(-10, -10)

The choice for I has now changed in row V for which the outcomes are now changed with +2 compared to the outcomes in Table 2. As a result, the optimizing strategy for I has changed from playing R to playing V resulting in a better overall outcome in Table 3 as now the top left is the new equilibrium.

We therefore conclude that the current policies for providing positive incentives (easier travelling, access to events) to people taking the vaccines will benefit the outcome of the decision-making process resulting in better outcome for society as a whole. The end stage could be that the group of people not taken the vaccine (G) is decreasing to such a size that the choice of G does not impact the outcome of society as a whole.