Epidemic control through incentives, lockdown, and testing: the government's point of view

Emma HUBERT, Department of Mathematics, Imperial College - London

Thibaut MASTROLIA, CMAP, École Polytechnique - Palaiseau

Dylan POSSAMAÏ, Mathematics department, ETH Zürich - Zürich
Xavier WARIN, EDF R&D and FiME - Palaiseau

In this talk, we consider the control of the COVID-19 pandemic from the point of view of a government. The spread of the epidemic can be modeled through either stochastic SIS or SIR compartmental models, but, for clarity, we will focus in this talk on the SIR model.

When the epidemic is ongoing, the population, who is considered as a single agent in this model, can reduce interactions between individuals in order to decrease the transmission rate β of the virus, and thus limit the epidemic. Indeed, the transmission rate depends essentially on two factors : the disease characteristics and the contact rate within the population. Although the population cannot modify the disease characteristics, each individual can choose (or be incentivised) to reduce his/her contact rate with other individuals in the population. Unfortunately, reducing social interactions is costly for the population. This cost takes into account both the obvious social cost, due to accrued isolation during the lockdown period, and an economic cost (loss of employment due to the lockdown, ...).

Therefore, the government can put into place incentive policies to encourage the lockdown of the population. In addition, the government may also implement a testing policy in order to know more precisely the spread of the epidemic within the country, and to isolate infected individuals. The interaction between the population and the government is modeled through a principal-agent problem. More precisely, given the population's problem, we are able to determine the optimal form of the tax policy χ. Given this tax policy χ, and an arbitrary testing policy α, one can solve the population's optimisation problem, and thus find the optimal transmission rate, namely $\beta^\star(\chi, \alpha)$. Then, finding the optimal tax and testing policy from the government's point of view is equivalent to solving an Hamilton-Jacobi-Bellman equation.

We provide numerical examples and compare the results with those obtained in two benchmark cases : one where the government can directly choose the optimal transmission rate (first-best case), the other where there is no incentive from the government. The numerical results confirm the relevance of a tax and testing policy to improve the control of an epidemic. More precisely, if a tax policy is put into place, even in the absence of a specific testing policy, the population is encouraged to significantly reduce its interactions, thus limiting the spread of the disease. If the government also adjusts its testing policy, less effort is required on the population side, so individuals can interact almost as usual, and the epidemic is largely contained by the targeted isolation of positively–tested individuals.

Based on the joint work [1].

[1] E. Hubert, T. Mastrolia, D. Possamaï, X. Warin. *Incentives, lockdown, and testing : from Thucydides's analysis to the COVID–19 pandemic.* Preprint arXiv :2009.00484, 2020.

Contact : e.hubert@imperial.ac.uk