Journal of Economic Dynamics & Control 140 (2022) 104314

Contents lists available at ScienceDirect

Journal of Economic Dynamics & Control

journal homepage: www.elsevier.com/locate/jedc

Comment on Optimal management of an epidemic: Lockdown, vaccine and value of life'

Piero Gottardi

University of Essex, United Kingdom and University of Venice, Italy

ARTICLE INFO

Article history:
Available online 20 January 2022

Keywords:
Pandemic
Stay at home policies
Vaccine
Behavioral responses
Externalities

1. Overview and contribution

The paper contributes to the recent literature which analyzes policy interventions aiming to mitigate the diffusion of the virus in an epidemic, while taking into account the effects on economic activity. To this end, it follows a line pursued also in various other works cited in the paper, by integrating an epidemiological model into a simple dynamic macroeconomic model. The interventions considered are restrictions on employment (stay at home policies, partial lockdowns,...) and the vaccination rate when a vaccine becomes available. The first ones limit the diffusion of the virus but also lower the output level. The arrival of a vaccine against the virus is modeled as a random, exogenous event; once a vaccine becomes available, the rate at which individuals are vaccinated provides another instrument to limit the diffusion of the virus but also entails costs in terms of resources. The diffusion of the virus in the population is modeled via a variant of a SIRS epidemiological model. New infections depend on exogenous parameters, which reflect the level of social interaction among individuals (at work and outside work) as well as the contagiousness of the virus, state variables describing the current level of infection and only one endogenous, policy variable, which is the fraction of the population forced to stay at home. The persistence of the virus and the number of deaths also depend on exogenous parameters, which describe the recovery rate/fatality rate and the expected duration of acquired immunity, and state variables. These parameters are constant, except for the fatality rate which is increasing in the mass of infected individuals in the population, to capture the pressure on the hospital system. This is one innovation of the paper in the epidemiological component of the model, the second one concerns the consideration of the changes induced by the (possible, future) availability of a vaccine.

The effect of a stay at home policy intervention is to reduce the level of social interaction among individuals and hence the level of new infections. At the same time, it slows down the decrease of the mass of susceptible individuals and so extends the length of time the virus persists in the population. Given the presence of a capacity constraint on the health system the intervention, by 'flattening the curve' of infections in the population, may allow to reduce the number of deaths due to the pandemic. When a vaccine becomes available, this provides an alternative way to increase immunity in the

E-mail address: piero.gottardi@essex.ac.uk

https://doi.org/10.1016/j.jedc.2022.104314

population, without having to go via infections and recovery. This in turn has an interesting positive feedback regarding the benefit of stay at home policies when a vaccine does not yet exist: a lasting reduction of fatalities in the population may be achieved with a tougher restrictive intervention in the initial phase, betting on the production of a vaccine in the near future, when the chances of this happening are sufficiently high. Both the new features in the epidemiological model mentioned at the end of the previous paragraph provide then a possible justification for some stay at home policy intervention, aiming to reduce the total number of fatalities due to the epidemic.

The model considered in the paper also examines the economic consequences of the epidemic and of the policy interventions aimed to mitigate its effects. The level of output and consumption is in fact reduced both by the current level of infection, as the infected individuals who are identified as such cannot work, and by stay at home policy interventions, which limit the ability of individuals to work and so actively contribute to production. Such interventions thus lower output when they are in place but have a beneficial effect on future output if they allow to reduce the level of infection in the population. Vaccinating individuals, when this becomes possible, also contributes to increase output, by lowering infections, but the cost of doing so reduces the fraction of output that can be used for consumption. The net effect on individual consumption may thus be ambiguous, at least until a sufficiently high level of immunity in the population is reached.

In the paper alternative scenarios and policy interventions are assessed on the basis of a welfare criterion given by the present discounted utility of individual consumption at any point in time, minus the social costs of deaths due to the pandemic over time. This means that the economic effects of the epidemic and the policy interventions considered are assessed together with the effects on the number of deaths. On the basis of the effects as briefly summarized above, we can see that some trade-offs between these two kinds of objectives may emerge in the determination of the welfare maximizing pattern of policy interventions.

The model considered proves quite tractable and in the paper some analytic results on the properties of the optimal policy and associated steady state outcomes are derived, together with a quantitative characterization of the evolution of the pandemic and economic variables along the transition to a steady state for a variety of scenarios. The latter also provides a clear illustration and quantification of the trade-offs described above. In particular, when the acquired immunity does not decay too fast, stay at home interventions are optimal at the onset of the pandemic (when the capacity of the hospital system proves a binding constraint), but interventions are temporary and do not occur in the steady state. It is then optimal to vaccinate at a high rate right after a vaccine becomes available. Also, the social value of a vaccine tends to decrease over time as the level of immunity acquired in the population increases. The quantitative features of the optimal interventions along the steady state are rather sensitive to the specification of parameters regarding the pandemic as well as the social cost of deaths.

2. Comments and suggestions

Various interesting insights can be learnt from the analysis in the paper. The simplicity but richness of the model considered allows to clearly see some key drivers of the dynamics of the pandemics and the trade-offs faced by policy interventions aiming to reduce the number of deaths while taking also into account the economic costs of such interventions. Also, the consideration of the possible arrival of a vaccine in the future proves to have quite interesting effects on the pattern of optimal policies. In what follow I will discuss some possible extensions and comment on some features of the model and interpretation of some findings.

Behavioral responses

In the model considered agents have no choices, the evolution of the pandemic and the associated dynamics of output and consumption depend on exogenous parameters and policy variables. The utility of the representative individual at any point in time is however affected by the level of infection, which influences the mass of workers unable to work after becoming infected and hence the output level. The chance of getting infected also affects the probability of death for an individual and enters then the expression of the utility of a representative individual in the population. Given this, it would seem natural to think that individuals may want to modify their own behavior in the light of the pandemic. In the framework considered in the model, that would mean changing their social interaction choices, summarized by the (exogenous) parameter β, by choosing to reduce contacts among them, as well as by modifying their mode of work, for instance by reducing the number of hours worked or by shifting to work from home. The latter may also be the consequence of firms' choices, leading to the adoption of new modes of organization of their production and of measures (possibly costly) which allow to reduce the chances of infections occurring among their employees. The incentives for firms to take such actions is that workers who fall sick are unable to work and this has a negative effect on firms' output. Altogether these actions have a somewhat similar effect to mandatory stay at home policy interventions. Extensions of the SIRS model to include behavioral responses have been explored in some recent papers (see e.g. Farboodi and Shimer (2021)).

The point has important implications for the need and design of policy interventions aiming to mitigate the effects of the pandemic, as the ones considered in the paper. If in fact individual agents respond to the risk of getting infected by modifying their behavior and firms also take measures to limit the chance of their workers getting infected, ignoring such responses may induce policy interventions to overshoot their objectives. Carrying the argument a little further, one may question whether any policy intervention is actually needed. If each individual takes into account the effects of her social interaction choices on her own risk of getting infected, and so do firms for the effects on their own employees when they decide the organization of their production activity, doesn't this suffice to achieve a socially efficient outcome? The answer of course also depends on what is the social welfare objective that is considered.

If this were the same as the utility of the representative individual in the economy, policy interventions would be justified in the presence of externalities not internalized by individuals and firms. It seems natural to argue that various kinds of externalities are present in the environment under consideration. The social interaction choices of an individual affect in fact not only her chance of getting infected but also that of the other agents with whom she is interacting as well as the firms employing her and these other individuals. Moreover, the probability of death of an individual also depends on the total level of infections in the population, in particular whether this is below or above the capacity of the hospital system. All these additional effects are likely not considered by individuals in their own decisions. Similarly, firms may not take into account the effects of the decisions they take regarding the organization of their production on the utility losses due to infections among their employees or other individuals and firms. All these externalities suggest that individuals and firms may underestimate the consequences of their decisions on the spread of infections in the society and hence that some policy intervention to limit contagion may be socially optimal.

Such interventions may take the form of the imposition of direct constraints on the social interaction or production choices of individuals and firms, as the ones considered in the paper. But other more indirect forms of interventions, aiming to induce individuals and firms to properly internalize those externalities, could also be envisaged (see Bisin and Gottardi (2021) and Kaplan et al. (2020) for contributions in this direction).

Social welfare objective and value of life

The social welfare criterion considered in the paper differs from the utility of the representative individual in the economy in the specification of the cost of death. This is taken to be a (linear) utility loss, proportional to some multiple of the loss in consumption due to death, possibly with different weights depending on whether or not the death is due to the fact that hospital capacity has been reached. If this differs and, say, is bigger than the utility loss due to the risk of death perceived by the representative individual in the society (equal to the expected utility of consumption lost because of death), it would mean that, in an environment as the one considered where all individuals are ex ante identical, each individual underestimates the social value of her own life and takes then insufficient precautions to protect it. This needs in my view a proper justification. The departure from the utility of individuals opens in fact to paternalistic forms of interventions, beyond the ones discussed in the previous section aimed to internalize externalities.

Value of vaccine

The paper provides some interesting insights regarding the effects that the possibility that a vaccine may arrive in the future has on present policy interventions as well as the benefits for society induced by the arrival of a vaccine. In this regard it shows that the social benefits of a vaccine are smaller if the vaccine arrives later rather than sooner in the pandemic. The reason is that the mass of susceptible individuals gets smaller as the epidemic progresses. Even though the arrival of a vaccine is modeled as an exogenous stochastic process, the authors draw some implications from these findings for the incentives of firms to invest in the development of a vaccine. If the reward for such investment were only the market value of the patent of the vaccine and this were to decrease over time, in line with the social value of the vaccine, firms would respond by intensifying their investments in the development of the vaccine at the onset of the pandemic. Why should we then think that firms' incentives are not aligned with the conditions for a social optimum and a policy intervention is needed to steer firms' investment in the right direction? Is there a reason to think such a problem is more severe for the development of a vaccine in a pandemic than for other medicines? These are clearly very interesting questions and a proper answer clearly goes beyond the scope of the current paper.

References

Bisin, A., Gottardi, P., 2021. Efficient choices in an epidemic. J. Public Econ. 200.
Farboodi, M.G.J., Shimer, R., 2021. Internal and external effects of social distancing in a pandemic. J. Econ. Theory 196.
Kaplan, G., Moll, B., Violante, G., 2020. The great lockdown and the big stimulus: tracing the pandemic possibility frontier for the U.S. working paper.