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Subject:
The link between the economic and health consequences of a virus outbreak

Economics and research

Summary

- We study the interactions between the economic and health consequences of a virus outbreak using an epidemiology model integrated into a macroeconomic general equilibrium model.
- The virus outbreak causes a deep recession, even in the absence of a lockdown, as households take self-preservation measures and reduce consumption and hours worked.
- Optimal containment policy requires an immediate lockdown. Although this worsens the recession, it also lowers substantially both the number of infected people and long-run death toll (i.e. 'flattens the curve').
- Prematurely lifting containment measures only provides a short-lived economic recovery: as economic activity returns, more people interact and become infected. The latter raises self-precautionary measures, prompting another recession. A gradual exit outperforms an abrupt exit.

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1. Introduction

While social distancing measures help contain the spread of the COVID-19 virus, they also imply hefty economic costs as households are required to cut back on consumption and firms are required to scale down production. These costs could reach a critical point at which policymakers might feel compelled to prematurely lift containment measures (gradually or abruptly) and resume business as usual.

To get a grip on both the economic and health consequences of the epidemic, the associated containment measures and exit strategies, we use a novel model that incorporates a standard epidemiology model within a macroeconomic general equilibrium model. Epidemiological models are typically used by institutions like RIVM to study population dynamics following a virus outbreak, yet do not account for endogenous economic behavior. The model used here, which was developed very recently, addresses this shortcoming. It is a stylized and parsimonious model to provide qualitative predictions. A (challenging) next step is to develop a more rigorous model, featuring nominal and real frictions, a financial sector, economic stabilization policies (especially on the monetary policy side), open economy dimensions, uncertainty, etc.

When calibrated to the Dutch economy, the model predicts an optimal containment policy that immediately and aggressively constrains economic activity in response to the virus outbreak. Only once the infection rate starts to wane are containment measures slowly lifted. Containment causes a substantial drop in consumption and a prolonged recession ensues. However, compared to a scenario without containment measures, the optimal policy brings down significantly the peak number of infected people and the long-run death toll, implying a relatively higher long-run level of real GDP. Prematurely ending containment yields a short-lived economic recovery as households increase consumption and hours worked. However, as economic activity returns and interactions among people intensify, the infection rate rises once again, causing another recession as people take self-preservation measures by staying home.

From a welfare perspective, that balances the utility gain from higher consumption against long-run health risks, our results make clear that, although containment measures generate (enormous) economic costs in the short run, they can save thousands of lives, which benefits the economy in the long run. Containment should therefore not be lifted too quickly.

2. Methodology

The model incorporates the canonical epidemiology (SIR) model within a simple general equilibrium model.[1] The SIR model describes population dynamics over time after a virus outbreak: some people are susceptible to the virus (S), others are infected (I); the latter either recover (R) or die (D) from the virus. Normally, the probabilities of transitioning between these four states are assumed to be constant and unrelated to economic conditions. In the model we use, however, the probability of becoming infected is endogenously determined by economic

[1] The model is based on Eichenbaum, Martin S., Sergio Rebelo, and Mathias Trabandt (2020). The macroeconomics of epidemics. NBER Working Paper No. 26882. National Bureau of Economic Research.

decisions: the more people consume and work outside their homes, the more they interact with others, which raises the likelihood of becoming infected. Conversely, the latter discourages people from consuming and working as much as they would normally have done.[2] The standard SIR-model is therefore likely to predict a higher infection rate and death toll, since it does not take into account this endogenous behavior of agents. Furthermore, we allow the death rate to rise with the number of infected people, reflecting capacity constraints in the healthcare system. Finally, the model features the probability that effective medical treatment (that cures the infected) or a vaccine (that protects those who are susceptible) are discovered. This probability causes people to consume and work more, as the risk from being infected and dying falls.

Despite its simplicity, the model is well-suited to illustrate how the economic and health consequences of the epidemic interact. It also allows us to study the effects of (optimal) containment measures and various exit strategies. Containment policy is modelled as a tax on consumption.[3,4] Because people within the model do not internalize how their actions affect the infection and death rates of others, we can solve for the optimal containment policy that deals with this externality. Optimal policy maximizes the aggregate (weighted) long-run value of life of susceptible, infected and recovered people, which depends positively on consumption and negatively on hours worked, and takes into account the probability of transitioning to the I, R or D states. We calibrate the model for the Dutch economy and run simulations for 250 weeks, with and without containment policy. We assume that, initially, 0.1% of the population is infected and that, in the standard SIR model, the total share of infected people in the long run (i.e. after the epidemic) is 60%.[5]

[2] Importantly, the transition probabilities are perfectly known by agents. Of course, uncertainty with regards the health status could also affect economic behavior.
[3] This is a crude way of distinguishing between the strict and loose containment policies that are implemented in real life. Alternatively, one could think of an income tax or sector-specific tax to capture such containment measures. We leave this for future work.
[4] Receipts of the consumption taxes are returned to the household in the form of lump-sum transfers. In each period, the policymaker faces a balanced budget (i.e. no debt is issued).
[5] Of course, the results differ quantitatively under alternative calibrations. Qualitatively, however, the results are robust.

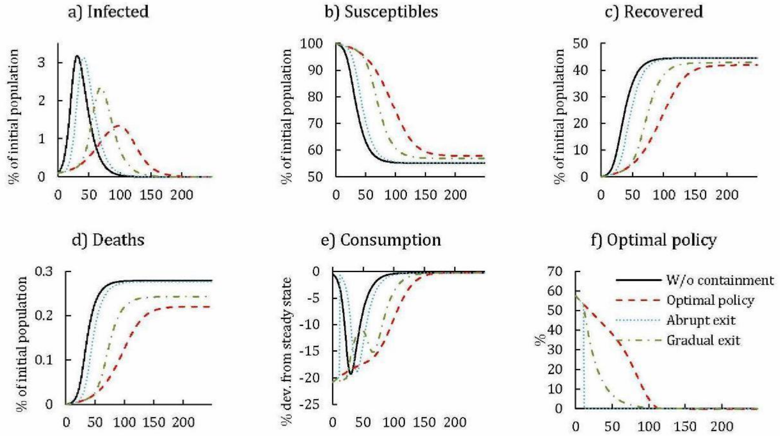
3. Results

Figure 1 shows the population and economic dynamics following the virus outbreak. As the infection rate and death toll rise, a V-shaped recession ensues *even in the absence of containment measures* (black solid lines) as households take self-preservation measures and reduce consumption and hours worked. Through these demand and supply effects, production and income fall, which exacerbates the recession. Note that the size of the recession is most likely understated, since this model assumes perfectly flexible prices and no real frictions, such as investment-adjustment costs.[6] Over time, less people are susceptible and so the infection rate falls, the death toll stabilizes and economic activity slowly resumes. The death toll implies a permanent reduction in the population, labor supply and level of real GDP.[7] The epidemic thus entails a real, long-run economic cost, even if no containment measures are taken.

Optimal containment policy requires an *immediate and aggressive restriction on economic activity* (red dashed lines).[8] Although this leads to a more severe and long-lasting recession than in the case without containment, the optimal policy 'flattens the curve': the peak number of infected people is reduced substantially and pushed into the future, and the long-run death toll is much lower. The latter further implies a relatively higher long-run level of real GDP. The optimal containment measures are meant to obtain a sufficiently large fraction of recovered people, which is necessary for the population to reach herd immunity. Thus, the measures are lifted only once the number of infected people exceeds its peak. Note that, because a vaccine or medical treatment is never actually discovered in the model, it may take up to two years before containment is fully lifted. Such a long stretch may not be politically feasible in real life.

[6] Moreover, a rise in firm bankruptcies and non-performing loans would likely also amplify the economic effects of the virus outbreak.
[7] Clearly this result also depends on the demographics of the economy in question. The model abstracts from age considerations and we leave this for future work.
[8] Due to the prospect of a vaccine being discovered, and because vaccines only protect susceptible people (but do not cure the infected), containment should be introduced *immediately* to limit the number of infected people. If the probability of a vaccine was zero, then containment should be introduced gradually, tracking the number of infected people.

Figure 1. Economic and health consequences of the virus, with and without containment policy



Note: Horizontal axis = weeks. Subfigure f) shows the (optimal) consumption tax.

At the time of the writing, governments around Europe have started lifting some of the containment measures to avoid a (self-induced) deep recession and political backlash. We therefore also examine the effects of a premature exit from optimal containment measures. The exit can either be abrupt (blue dotted lines) or gradual (green dashed-dotted lines). Proponents of an abrupt exit point to the benefits of a quick economic recovery, whereas those in favor of a gradual exit caution against the public health costs of lifting containment measures too quickly. We consider an exit from optimal containment after 12 weeks.[9]

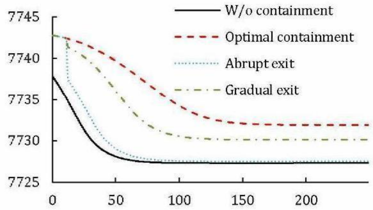
Both the abrupt and gradual exit from containment yield a short-lived economic relief as households start consuming more. However, this also leads to a sharp increase in the number of infected people, as more people interact, which

[9] The timing of the exit is chosen randomly. We assume that, under a gradual exit, containment measures are lifted according to a persistent first-order autoregressive process.

in turn causes a higher death toll than under optimal policy and a *second* recession. This W-shaped economic recovery is much less violent under a gradual exit than under an abrupt exit, implying a more smooth consumption path. Moreover, the peak number of infected people and the death toll are significantly lower under a gradual exit than under an abrupt exit. Note that the epidemic is less severe when containment measures are lifted prematurely (either abrupt or gradual) than if no measures are taken at all.

Figure 2 shows the effects on aggregate welfare, which balances long-run household consumption against long-run health risks. Despite generating a more prolonged economic recession, welfare is highest under optimal containment as it minimizes the number of infected people and the death toll, which translates into the smallest loss in long-run real GDP. Abruptly exiting containment has a similar effect on long-run welfare as taking no containment measures.

Figure 2. Aggregate welfare following the virus outbreak



Note: Figures are shown in present value terms.

4. Conclusion

According to the SIR-macro model, a virus outbreak creates a deep and protracted recession, even in the absence of any containment measures, as households stay home to avoid becoming infected. It also entails a permanent decline of the population and in real GDP. Optimal containment policy worsens the recession through an immediate lockdown, yet raises welfare by limiting the death toll and long-run loss in GDP. Only once the infection rate exceeds its peak, and the population reaches herd immunity, ought the containment measures be lifted.

Prematurely exiting containment only provides a short-lived economic gain and leads to a higher long-run death toll compared to the optimal policy. If a premature exit is unavoidable (e.g. due to increasing political pressures), then a gradual exit is preferred over an abrupt exit.