The Role of Contact Tracing in the Long Pandemic War

By Leonardo Melosi and Matthias Rottner*

As progress to reach herd immunity against the coronavirus seems to languish, contact tracing may be a valuable tool for policymakers to contrast a prolonged pandemic crisis. This column studies contact tracing in a new macro-epidemiological model with asymptomatic infection and limited tracing and testing capacity. We find that contact tracing is generally very effective to contain the spreading of the virus. Critical to this success is the reconstruction of the infection links of the confirmed infected cases, which facilitates the task of quickly detecting spreaders.

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Introduction

Low global vaccination rates, the emergence of new variants of the coronavirus, and breakthrough infections are proving to be major long-lasting obstacles to end the pandemic.[1] As the war to the virus appears to be unwinnable, policymakers may want to consider alternative tools to minimize the economic costs and the death toll of this long-running pandemic. In this column, we study the efficacy of contact tracing; that is, a testing strategy based on tracing and testing the contacts of confirmed infected cases.

In recent research (Melosi and Rottner 2021), we construct a macro-epidemiological model with asymptomatic transmission to study under what conditions contact tracing is an effective tool to combat the spreading of the virus. We formally define contact tracing as a testing strategy resting on ex-post reconstructing a share of the network of interactions of confirmed infected cases. Positive cases are quarantined so that they cannot infect anyone else. The testing and tracing capacity is assumed to be limited.

Our model suggests that a critical challenge to the effectiveness of contact tracing is an externality that can lead to the collapse of the tracing and testing system. More specifically, people tend to entertain economic and social interactions at rates exceeding policymakers' ability to trace, test, and isolate the close contacts of confirmed cases. If the tracing and testing system collapses or not as a result of this externality, it depends on how comprehensive the tracing technology is (i.e., how many periods back contacts can be traced) and the ability of a country to quickly scale up its testing capacity.

Containment policies can be used to mitigate this externality and allow policymakers to buy time to expand the tracing and testing scale in order to preserve the viability of the tracing and testing system. Particularly at the early stages of a pandemic crisis when testing capacity is fairly limited, the combination of contact tracing and well-calibrated containment measures is critical for policymakers to successfully contain the spreading of the virus and to mitigate the associated economic costs. If containment policies successfully protect the viability of the tracing system, there is no trade-off between economic performance and public health during a pandemic.[2] This result is particularly important when pandemic crises are prolonged.

Provided that this externality threatening the viability of the testing system is under control, we find that contact tracing allows policymakers to effectively mitigate the worst consequences of a pandemic. A typical challenge when using tests to preemptively halt sudden rise in infections is that at the onset of a pandemic, spreaders are only few and thereby their interactions represent a negligible share of the total economic interactions. Consequently, these interactions are hard to detect via random or uninformed testing and, indeed, these naïve testing strategies typically fail to halt the spreading of the virus.

Contact tracing can overcome this challenge by exploiting the information contained in the reconstructed network of interactions of confirmed infected cases. Leveraging this information is critical because it increases the chance to detect those subjects who have been infected by the confirmed cases (infection links). Furthermore, detecting and quarantining agents who have been infected *only very recently* is critical to contain the infection rate because these subjects did not have much time to infect other subjects. As a result, contact tracing – even

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[1] Fisher et al. (2021) estimate the COVID-19 shock in an empirical Dynamic General Equilibrium (DSGE) model of the United States and find that the effects of the pandemic on real activity and the labor market are quite strong and persistent.

[2] Relative to the literature about the trade-off between public health measures and lockdowns (e.g., Alvarez et al. 2020; Aum et al. 2021), our emphasis is on the importance of keeping the tracing and testing system viable.

when the tracing technology allows health officials to reconstruct only the very recent contacts of confirmed cases – is shown to be an effective tool to contain the spreading of the virus. Nevertheless, a more comprehensive tracing technology allowing health officials to trace contacts that happened in a more distant past renders the tracing and testing system more resilient to the threats posed by consumption and labor externalities.

Economic Activity and the Endogenous Network of Interactions

In Melosi and Rottner (2021), we build a dynamic general equilibrium macro-epidemiological framework, in which infected agents may not show any symptoms of the disease and the availability of tests to detect asymptomatic spreaders is limited.[3] The novelty of our framework is the incorporation of an endogenous network of interactions of confirmed infected cases that depends on economic decisions. This setup allows us to evaluate the economic and epidemiological impact of contact tracing, which is a testing strategy that aims to reconstruct the infection chain of newly symptomatic agents.

In the model, agents who become infected do not have any symptoms at first. While they remain asymptomatic, they do not know that they are infected and, therefore, keep consuming and working exactly as when they were not infected. In doing so, they create a network of contacts with other agents through which they silently spread the virus. When they turn symptomatic or when they get tested, these spreaders are detected and quarantined by the health authorities so that they cannot infect anyone else. Contact tracing tries then to reconstruct as much as possible of the newly symptomatic cases' infection chain. This reconstruction forms the basis to decide who to test. The objective of testing is to detect as many asymptomatic spreaders as possible and quarantine them.

## Contact Tracing vs Random Testing

When the epidemiological and economic parameters of the model are calibrated to match the U.S. data during the COVID-19 pandemic, we find several interesting results. Contact tracing – even when tracing is limited to close contacts that occurred the week when a subject starts showing symptoms – considerably improves the ability of health authorities to control the spread of the pandemic relative to a strategy based on randomly testing the population as suggested by Romer (2020) among other scholars. This is illustrated in Figure 1, where the evolution of the pandemic and the economic activity is compared across three scenarios: no testing, contact tracing, and weekly random testing one fifth of the U.S. population.[4]

The prediction is in line with empirical findings by Fetzer and Graeber (2021), who show quasi-experimental evidence that contact tracing is very effective in containing the spread of the virus. Unlike randomly testing the population, contact tracing exploits the existence of an infection chain connecting the newly symptomatic agents with the subjects they have infected in the current period. Therefore, contact tracing mitigates the spread of the pandemic and stabilizes output.

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[3] The model is built on the macro-epidemiological model introduced by the seminal contribution of Eichenbaum et al. (2021). This model does not feature asymptomatic infections and testing.

[4] The (endogenous) amount of tests required by contact tracing every week is considerably smaller: 5% of population at its peak.

Figure 1: Dynamics of key epidemiological and economic variables for different testing. The blue line shows the scenario when no tests are performed. The red dashed denotes the scenario when contact tracing is based on the assumption that only the close contacts that have occurred in the current week can be traced. The black dashed-dotted line shows the scenario in which policymakers randomly test the population. We assume that the weekly tests available for random testing is 20% of the entire population, which is considerably higher than the (endogenous) amount of tests required by contact tracing every week (i.e., 5% of population at most).
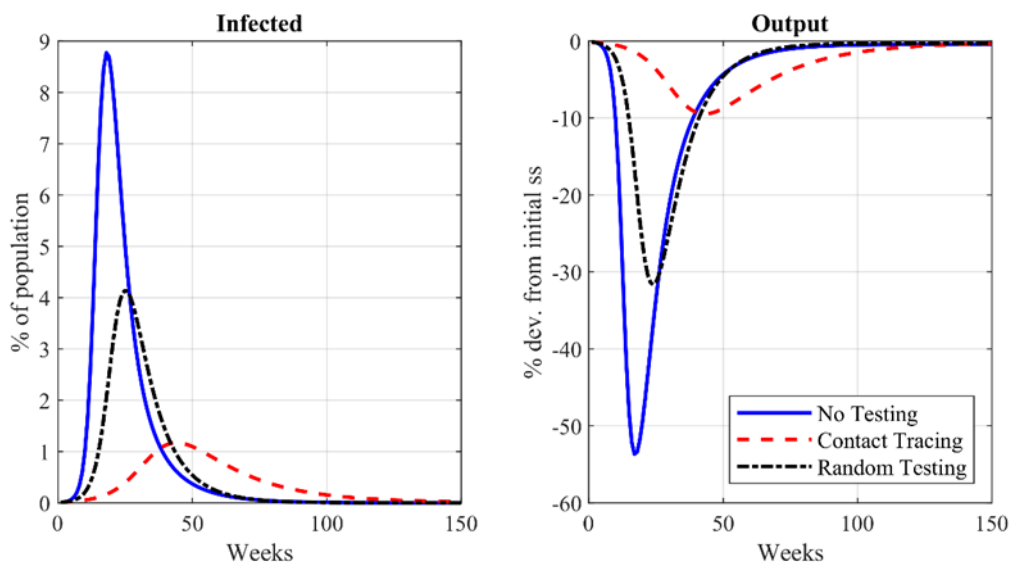

The success of contact tracing rests on resolving a critical challenge faced by testing: at the beginning of a pandemic spreaders are only few and are thereby hard to detect. As a result, it is very challenging for policymakers to prevent the rate of infection from soaring by relying on testing alone. Contact tracing allows policymakers to leverage the knowledge of the infection chains of the confirmed infected cases to improve the chance of detecting newly infected agents at the beginning of an outbreak or a new wave in an ongoing pandemic.

Tracing Externality and the Viability of the Tracing System

Contact tracing can be unsuccessful because of an externality that can lead to the collapse of the tracing and testing system. Specifically, agents fail to realize that their consumption and labor decisions have an externality on the number of subjects that health authorities have to trace and test in future periods. As a result, the consumption and labor decisions of agents may end up overburdening a tracing and testing system to the point of making it insufficient to contain the spread of the virus. With the demise of the tracing and testing system, the risk of becoming infected soars, and, consequently, agents reduce consumption and labor in an attempt to curtail their economic interactions. As a result, the economy experiences a sharp and severe contraction.

We assess the resilience of the tracing system by constructing a scenario where the contact tracing technology allows health officials to trace only the interactions that occurred in the current week. Testing capacity is calibrated using the number of tests performed in the US since March 16th, 2020. The pace at which the U.S. built up its testing capacity at the beginning of the pandemic would have not been fast enough to stop the rapid spread of the virus via contact tracing. Agents consume and work too much as they fail to realize that their individual consumption and labor decisions have negative externality on the viability of the testing system. As shown by the solid blue line (*Contact Tracing*) in Figure 2, the testing system collapses leading to a sudden drop in the probability of detecting asymptomatic infected agents (left plot) and to a severe recession (right plot).

Figure 2: Comparison of different testing strategies with limited tests. Basic contact tracing, shown as blue line, is based on the assumption that only the close contacts that have occurred in the current week can be traced. The red line marks the scenario where basic contact tracing is complemented with a lockdown enacted to pre-emptively save the testing system. The black dash-dotted line shows the scenario associated with an extended contact tracing technology, allowing policymakers to trace the close contacts that have occurred in the current week and in the previous week.
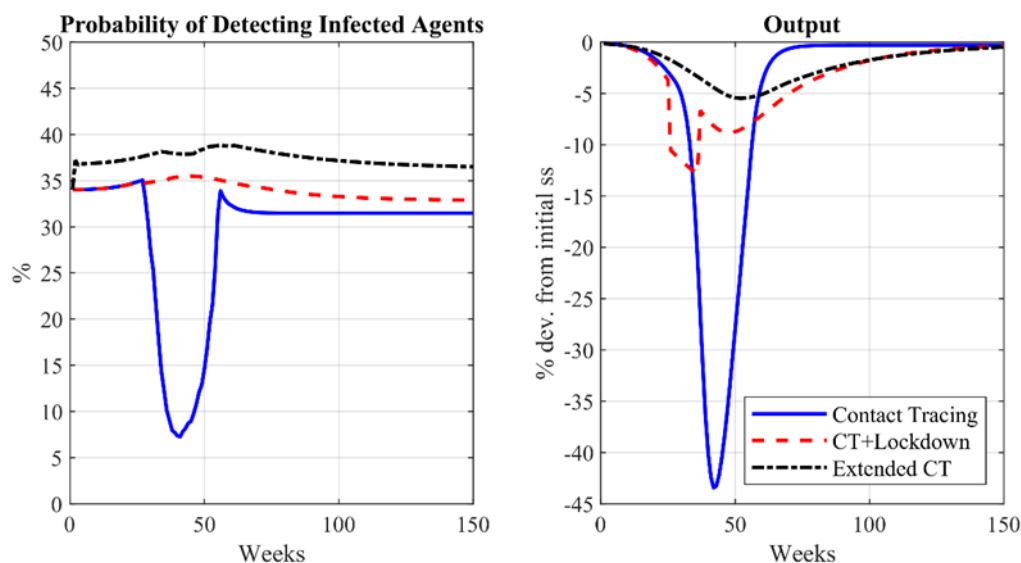
The testing system can be preserved by complementing contact tracing with a moderate lockdown enacted to pre-emptively save the testing system as shown by the red dashed line in Figure 2.[5] By ensuring the correct functioning of the testing system, the lockdown prevents a surge in the infection rate and the ensuing drop in output. This result underscores the existence of exploitable complementarities between lockdowns and testing as well as the critical importance of preserving the testing system for a successful management of the pandemic. The response of output highlights that if containment policies successfully protect the viability of the tracing system, there is no trade-off between economic performance and public health during a pandemic. This result is particularly important when pandemic crises are prolonged.

We then consider a more efficient tracing technology that allows health authorities to trace the contacts occurred in the current and in the previous week. This more comprehensive tracing technology gives health authorities a second chance to quarantine asymptomatic spreaders who could not be traced and tested in the previous periods. Managing to lower the number of asymptomatic spreaders early on reduces the amount of tests needed to be performed later on. It then turns out that, under this more efficient tracing technology, the pace at which the U.S. built up its testing capacity would have not made any containment measure necessary. As shown by the black dashed-dotted line in Figure 2, under this slightly more comprehensive tracing technology, there is no real trade-off between public health measures and output.

Conclusion

Contact tracing is a valuable tool to keep epidemics under control, especially when a pandemic crisis is long lasting. When the availability of tests is large enough or the tracing technology is sufficiently comprehensive,

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[5] The lockdown is characterized as moderate because its duration and scope is limited to an extent that is sufficient to preserve the testing system. The lockdown is implemented a few periods before the constraint on testing becomes binding.

contact tracing is shown to effectively contain the death toll and the economic costs of a pandemic. The key to success is the exploiting of the infection chain to quickly trace and isolate asymptomatic spreaders. However, a tracing externality combined with critical bottlenecks of the tracing and testing system may require complementing this tool with well-timed containment measures to alleviate the pandemic's tool on the economy and mortality. ■

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