Pandemics are as old as humanity, from the Black Death in Eurasia in the XIVth century to the worldwide Spanish flu after the first World War. They randomly kill people. They devastate our economy by reducing our ability to live from our labor due to the necessity of social distancing and lockdowns. The SARS-CoV-2 and its variants are particularly virulent viruses. Keep in mind that in the absence of a cure and of a vaccine, epidemiologists believe that the only way to end the pandemic is to build herd immunity, which requires probably around 80% of the world population to be infected, depending upon the new sanitary norms that will be adopted by human beings. If we assume that this is done in an orderly manner so that our health system is not overwhelmed (which requires a costly health strategy to “flatten the curve”), the existing statistics suggest that 1%–2% (depending upon the variant) of the infected people will die from COVID-19. This suggests a death toll of at least 1% of the world population at the end of the pandemic in the absence of a cure or a vaccine. For the sake of comparison, the Black Death is believed to have killed at least one-third of the European population. This gives us an order of magnitude of the macropandemic risk in its life and health dimensions.

At least in the first waves of the pandemic, most countries have attempted to fight it with aggressive lockdowns and social distancing rules that had enormous economic and financial consequences. These policies hit individual and corporate incomes in diverse manners and intensities. These governmental decisions—not an act of God—wiped out the source of economic value creation entirely for people in large sectors of the economy, whereas other were in a situation to be able to continue to work in remote mode. Gross domestic product (GDP) losses measure at the macrolevel the magnitude of the pandemic risk in its economic and financial dimension. Under some estimates, the world GDP was reduced by 4.5% in 2020, and additional large losses are expected for 2021. This macroeconomic measure should not hide the fact that economic losses were highly concentrated in specific regions and economic sectors.

A full description of the risk should also require a probability distribution for the emergence of a pandemic every year. This is not an easy task, given the (hopefully) very low frequency of such events. Other global risks, such as in the domains of nuclear accidents, financial crises, or asteroids, face the same probability measurement issue. The absence of a consensual probability distribution makes the analysis and debate about the design of future health policies more complex. In this context, new information obtained from the occurrence of a pandemic should induce people and institutions to revise their beliefs. In the case of COVID-19, it seems that this did not happen, as the price of life insurance products have not been revised substantially (Harris et al., 2021).

In this short introduction of this special issue, I highlight some aspects related to insurance and risk management of pandemic risks.
1 | PANDEMIC RISK MANAGEMENT ISSUES

Two types of issues should be considered here: preventive actions before the virus occurrence, and the management of the pandemic itself. There is no doubt that states and the stakeholders of their health systems will have to rethink the way to prevent and self-insure against pandemic risks. There is little doubt too that judicial systems in various countries will be involved in evaluating ex post whether the executive branch of government could be held liable for the lack of preventive efforts or for the mismanagement of public health. In both cases, experts will have to evaluate the optimality of health policies. Did one have enough intensive care units in the hospital system? Did we have enough protection masks in reserve? And did we devote enough resources to support bio-medical research to build medication and vaccination capacities? These are particularly hard questions to answer, in particular in the absence of a consensual probability distribution of the pandemic occurrence. Under risk neutrality, the ICU/mask optimization problem is equivalent to an inventory problem that is usually referred in the O.R. literature as the “newsboy problem.” In the ICU context, a simplified version of the problem is as follows. The decision maker needs to determine the number \( x \) of IC units to create before knowing how many people will need them. Let \( y \) denote the ICU demand and \( F \) the cumulative probability distribution associated to this random variable. Let \( p \) denote the value of statistical life and \( c \) the unit cost of an ICU. For simplicity, let assume that all infected persons being treated in an ICU are saved, and all infected people without an ICU die. A risk neutral decision maker would select \( x \) to maximize the aggregate value of lives saved net of the investment cost of ICUs:

\[
\max_{x} W = pE[\min(y, x)] - cx.
\]

It is easy to check that the optimal solution must satisfy the following first-order condition:

\[
1 - F(x^*) = \frac{c}{p}.
\]

That is, the optimal ICU capacity is such that the probability of it being overwhelmed must be equal to the ratio of the unit ICU cost over the value of statistical life. Eeckhoudt et al. (1995) characterize the solution when the representative agent is risk-averse (and prudent). But obviously, as soon as ICUs—or masks—are costly, it is optimal to build a capacity which will be insufficient to guarantee that the capacity will never be overwhelmed. We should therefore recognize that the mere observation ex post of an insufficient ICU capacity be a demonstration of suboptimal decision ex ante. The application of the simple decision rule presented in the equation above requires knowing the distribution function \( F \), which is ambiguous in the real world. Under ambiguity neutrality, this rule should be satisfied in expectation, that is, using the expected probability function. The model should of course be enriched by the existence of other usages of ICUs, by the dynamic nature of the problem (ability to expand ICUs on demand, timing of the resolution of the uncertainty, ...), and by the heterogeneity of the health gains from ICUs for different health profiles (age, variant, comorbidity,...).

The other family of risk management issues is related to the selection of health policies to limit the welfare impacts of the pandemic once it occurred. Epidemiologists have been very reluctant to use their predictive models to make policy recommendations based on the conflicting objectives of saving lives and saving the economy. As all economists know, doing this
requires monetizing lives saved in a cost-benefit analysis. This reluctance forced economists to do the interdisciplinary effort to perform this task. Immediately after the emergence of COVID-19 in the western hemisphere, many economists used the standard epidemiological model Susceptible-Infected-Recovered (S-I-R) to test different dynamic health strategies, measuring lives and GDP lost of various strategies to identify the best policy under different calibrations of the model for the value of statistical life, the contagion parameter R0, the mortality rate, the proportion of telework, and so on. See for example, Acemoglu et al. (2020), Favero et al. (2020), and Gollier (2020). As soon as April 2020, the consensus emerging from these early papers was that the winning policy is an immediate and strong lockdown of 1 or 2 months followed by a testing-tracing-isolating strategy to extract the last traces of the virus in the population. The optimality of an age-based social distancing policy to protect the most vulnerable people and to build herd immunity with the less vulnerable people is also illustrated in that literature. Notice that economists have also measured the value of expanding the testing capacity in the early stage of the pandemic, in the absence of any other solution than the isolation of infected people.

The volatility of the R0 due to the emergence of more contagious variants made the calibration of these models quite difficult, killing many of these papers before they could be published. Moreover, I suspect that we vastly underestimated the cost and social acceptability of the eradication strategy based on an aggressive testing-tracing-isolating policy at the end of the pandemic, which would also require closing frontiers in a world of variable prevalence rates and lockdown policies across countries. The very early arrival of an efficient vaccine also changed the nature of the optimal strategy, in favor of policies that flatten the curve rather than those which tried an early eradication of the virus through a strong and prolonged lockdown. But it is another illustration of the well-known hindsight bias to evaluate ex post the efficacy of such policies on the basis of information (an early availability of an efficient vaccine) that were not available at the time of the decision.

Another key deficiency of these eco-epidemiological models comes from the assumed absence of uncertainty. In reality, the R0 of the historic variant was radically unknown in February 2020, and a relative optimism prevailed at that time about the dynamic of the virus in the western population. Ex post, it is easy to say that we were mistaken and that the mistake had dramatic consequences. No politicians dared to kill the economy for a few weeks at that time to eradicate a virus whose contagion and lethality were not taken seriously at that time by a vast majority of the people. In another scenario plausible at that time, the SARS-CoV-2 would not have been more contagious than the SARS-CoV-1, and the pandemic could have been resolved with light social distancing measures alone. We must be prepared for action in anticipation of the next lethal virus. Here again, determining the socially desirable strategy in the face of an unknown virus is a complex matter. In particular, one should solve dynamic S-I-R models with parametric uncertainty and dynamic learning, a rather complex task. The renewed perception that a pandemic may have catastrophic consequences just makes the appeal to new science-based health policy guidelines more urgent.

## 2 | PANDEMIC RISK-SHARING ISSUES

Given the fact that some people will be hit more heavily than others, in their health and in their wealth, there is a scope for welfare-improving mutualization schemes. Before knowing who will lose and who won’t, everyone would be made better off by entering into a mutuality agreement in which the global loss will be shared equally. But this global loss is potentially so
large that it is not likely that standard insurance mechanism based on premia paid ex ante to accumulate insurance reserves large enough for insurers to pay indemnities in case of a pandemic. This would mean creating insurance reserves as large as 10% of annual GDP. This is of course completely unrealistic. In addition, other standard insurability issues matter here (Gruendl et al., 2021). For example, the anticipation that uninsured people will benefit from various solidarity mechanisms reduces the willingness to pay for any private insurance mechanism ex ante. Also, remember that most economic losses from a pandemic is not the consequence of an act of God (the virus), but is rather triggered by a governmental decision. Therefore, it is not clear that a government would take account of the impact on the insurers’ financial health when evaluating the lockdown policy, creating a “hold-up problem.” Finally, there are obvious adverse selection and moral hazard problems in this context.

Thus, private insurance mechanisms could contribute to improving the allocation of risk in the economy only at the margin. One possible policy is to do a public-private partnership in which private insurers cover the first layer of risk and leave the coverage of the right tail of the distribution of the aggregate loss to the government and the taxpayers, in the spirit of risk-sharing mechanisms prevailing in many western countries to cover natural catastrophes. In the absence of such an explicit mechanism, most western governments have played the role of insurers of last resort, covering a large fraction of corporate losses and lost labor incomes through standard social security mechanisms or circumstantial “whatever it costs” policies.

The key insurability issue raised above comes from the positive correlation between the aggregate loss and changes in GDP. This positive CCAPM beta of the pandemic insurance product should make insurers quite reluctant to sell this product at an attractive insurance price. At the limit, if all citizens are symmetrically hit by the pandemic, sharing this risk is irrelevant and its mutualization breaks down in a no-trade equilibrium.

In the context of such low-probability large-loss risk, self-insurance mechanisms based on a combination of buffer stock savings and debt are highly relevant, as shown for example, by Gollier (2003). In no-loss years, consumers should raise their buffer stock of relatively liquid savings that would be used to smooth consumption in pandemic years. This self-insurance mechanism improves intertemporal welfare, but its efficiency is limited by the fact that many consumers would not be able to borrow from financial intermediaries when their buffer stock of liquid assets evaporated due to a larger-than-expected frequency or intensity of lockdowns. This is where the State can intervene, since it can often borrow at more preferential terms than its citizens. The “whatever it costs” policy of covering most economic losses from the lockdowns financed by raising the public debt did exactly that in 2020 in Europe and in Northern America, and this is also an intertemporal-welfare-improving policy. In these exceptional times, allowing households to liquidate a fraction of their pension savings provides an alternative solution, as in Chile (Lorca, 2021). In both cases, this raises the question of how to compensate these unexpected expenditures in the long run.

3 | CONCLUDING REMARK

This special issue explores some of these questions, from the insurability of pandemic risks to the impact of COVID-19 on the pricing of life and health risks. These works illustrate the reactivity of our profession to emerging social demands for science-based policy recommendations. For example, as soon as March 2020, TSE established a weekly internal webinar to discuss our new works on pandemic economics, with an average attendance
exceeding 50 researchers. Although many of these early works have been performed with very incomplete information, their results enlighten some crucial aspects of pandemic policies. There is no doubt that more work will have to be performed in the future, notably to extract new knowledges from data, or to introduce realistic sources of uncertainty in our models. But this collective experience makes me proud to be an economist.

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