Acronyme	**ECOVID-19**
Titre de la proposition	**Eco**nomic Epidemiology of **Covid-19**
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Organisme du coordinateur	Centre d'économie de la Sorbonne, UMR 8174 --- Maison des Sciences Économiques 106-112 bd de l'Hôpital 75647 Paris Cedex 13
Aide demandée	187 133, 76 euros
Coût complet	187 133, 76 euros
Durée	18 mois
Mots clés de la proposition	Economic activity, Economic Epidemiology, Cost-Effectiveness

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Abstract

ECOVID-19 aims to provide a comparative cost-effectiveness analysis (CEA) of public policies undertaken in real-life conditions during the Covid-19 epidemic in France. We will compare three main measures: i) confinement measures ii) testing with a specific focus on undocumented infections iii) reminders on the so-called "barrier gestures". To do so we will build a theoretical model of disease diffusion and test the model using quasi-experimental variation during the outbreak to evaluate the respective importance of policies and the timing of their implementation.

Our approach will be complementary to epidemiological models and other SHS projects previously selected by REACTing. Including individual trade-offs, learning, and externalities under uncertainty is indeed the main added value of economics in this field of research.

Our theoretical model will start from Adhvaryu (Review of economic studies, 2014) and Li et al. (Science, 2020) and will aim at quantifying the role of undocumented infections in France during the outbreak. Our focus will be on individual behaviors under belief-based uncertainty and the learning adaptive process during the outbreak.

Our empirical test will be based on Adda (Quarterly Journal of Economics, 2016) to estimate the relative cost-effectiveness of the above mentioned measures, while taking uncertainty and learning into account. Data on infections will come from two cohorts of patients: the "cohort of infected patients" (since the first patient treated on 01/24 in Bichat) and the "contact case cohort" managed by Santé Publique France. This data will be combined with school closure, transports limitation, public announcements dates on compulsory confinement, and Twitter volume peaks as a proxy for information campaigns. We will use a simple event-study approach combined with a fuzzy difference-in-difference to assess the effectiveness of such measures. To calculate the expected monetary benefits, cost estimates will be taken from the literature and data we will collect.

Our project answers concretely to the third priority of the proposal namely "Infection prevention and control measures in community settings" and to two sub-objectives: "Conditions of efficiency and real conditions for implementing information, prevention, care and control actions" and "Evaluation and modelling of prevention and control measures". This project brings together researchers who are among the best experts on the economics of health epidemics and human behaviors. The proposed team is limited to three researchers, one research assistant and one post-doctoral student to work efficiently and provide fast answers to relevant public policy questions in order to prepare future epidemics. Four external experts from different fields have been added in the governance of the project to receive feedbacks on our results.

1 Description of the proposal

1.1 General context

This project intends to address the third priority of the call for proposals entitled "Infection prevention and control measures in health care settings (including how best to protect health workers) and community settings" and more specifically two secondary objectives:

1. Conditions of efficiency and real conditions for implementing information, prevention, care and control actions
2. Evaluation and modelling of prevention and control measures.

The COVID-19 pandemic is first and foremost a human tragedy, infecting more than 203,529 cases and killing more than 8,200 people as of March 18, 2020. However, the virus has also hit society hard, disrupting travel, cutting off communities, shuttering factories and shaking up economic markets. The public policy measures are unprecedented since the end of the Second World War.

Viruses impose a cost on society, through premature deaths, long-lasting morbidity (Almond 2006), increased health-care utilization, and loss of schooling or hours of work. Epidemics may have different consequences on economic activity. First, for obvious health reasons, workers' activity is limited during the outbreak, all the more if the working age population is more affected. Health epidemics will thus have direct, indirect and opportunity costs. Second, a more pernicious effect on beliefs will lead actors to anticipate or postpone certain economic decisions. Consumption of basic commodities may be accelerated but investment decisions will be postponed. Third, long term effects may appear many decades after such as the effects on human capital accumulation (Kuecken et al., 2020). Lastly, the economic crisis generated by the health crisis may, in turn, have health effects, all the more if social policies are not well developed in a country.

Conversely, economic activity and public policies may have several consequences on the spread of diseases. First, public policy measures such as school closures, quarantines or transport limitations will slow down economic activity, but aims at reducing the cost of epidemics that will in turn affect point 1 above. Second, public policies may also generate perverse incentives that need to be evaluated. From a macro viewpoint, economic activity (measured for instance by unemployment or foreclosures) may have ambiguous effects (Brüning and Thuilliez, 2019).

The principal objective of ECOVID-19 is to provide a comparative analysis of the cost-effectiveness of public policies undertaken during the Covid-19 epidemic in France under real-life conditions. We will compare three main measures: i) confinement measures ii) testing with a specific focus on undocumented infections iii) the so-called "barrier gestures" and associated communication. Some of the direct question related to this goal are:

1. Are confinement measures more cost-effective than testing or simpler prevention methods such as reminders on best practices? Does the timing of intervention matter?
2. What was the role of undocumented infections in France during the outbreak?
3. How individuals and policy makers adapt and learn during a crisis?

We will provide a number of methodological and theoretical contributions to the analysis of the cost-effectiveness of public policies during an epidemic outbreak. The first one will be to provide a diffusion model that will include individual trade-off under belief-based uncertainty and the learning adaptive process during the outbreak (Bennet, 2015). The second one will be to provide reliable estimates of the cost-effectiveness using quasi-experiments. Lastly we will provide a heterogeneity analysis. Doing so we will explore the correlation of the share of undocumented cases with population characteristics and heterogeneity of the treatment effect of the above mentioned policies.

1.2 State of the art: the economics of health epidemics

There is a long history of quarantines aimed at preventing the spread of diseases, dating back at least to the plague epidemics in Europe and Asia in the Middle Ages; quarantines were also used in Bretagne in 1954 during the smallpox outbreak or selectively during the Ebola outbreak in 2014. There is also an extensive literature evaluating the effect of public health reminders on prevention and treatment. However, massive testing policies have been much less analyzed. Curiously, the optimal combination of testing strategies, reminders and confinement has also been much less examined.

In European societies, fully binding measures or tracking procedures were probably difficult to enforce without experience and preparation. People make trade-offs based on the risk of infection, the risk of dying, their environment and the cost of being confined at home. During the Covid-19 epidemic, incivility and disobedience were observed, forcing the authorities to fine. This example suggests that first uncertainty was high to make optimal decisions and second, externalities were not fully considered by individuals. Many experts also argue that aggressive tracking, surveillance and testing might be much more cost-effective than confinement. Although it is clear that we need more testing and surveillance, the optimal timing and combination of confinement, testing and public communication efforts is far from being understood.

Let us explain what is the added value of economics in this area. Economic epidemiology is a field at the intersection of epidemiology and economics that incorporates incentives for healthy behavior and their attendant behavioral responses into an epidemiological context to better understand how diseases are transmitted and could be controlled. Economic epidemiology takes into account externalities. An externality is an economic term referring to a cost or benefit incurred or received by a third party. Including individual trade-offs, learning, and externalities under uncertainty is thus one the main added value of economics in this field of research.

The literature in epidemiology has developed models of disease diffusions dating back to Kermack and McKendrick (1927). However, work in epidemiology provides little theoretical and databased evidence on the cost-effectiveness of policies aiming at reducing population contact rates, or better detection of asymptomatic cases. This is particularly important from a policy maker perspective to implement a comprehensive approach that takes social and economic costs into account. The optimal combination, the timing and parameters of interventions indeed help slowing down Covid-19 transmission and flattening the curve.

1.3 Work packages (WP) and deliverables

1.3.1 WP1: An economic epidemiological model of the spread of SARS-COV-2 including uncertainty.

1.3.1.1 Covid-19 diffusion Model

A critical characteristic of the current crisis is the extent of uncertainty. Covid-19 basically works via human-to-human transmission, but as excellently analyzed in Li et al. (2020), a key exceptional feature of this epidemic is that a substantial fraction of infected individuals are asymptomatic and remain undocumented. If testing is not systematic, these individuals act as the most dangerous engine of contagion as demonstrated in the above mentioned article. Any acceptable model of Covid-19 diffusion should pay particular attention to this class of individuals, which should be better characterized for a more accurate appraisal of the overall epidemiological dynamics. This would ultimately allow for better estimates of occurrence of new cases. We shall try to adapt to the available French data the work of Li et al. (2020).

1.3.1.2 Coping with the uncertainty inherent in the current Covid-19 crisis: a model of individual behavior in the face of epidemic uncertainty

The economic analysis can also contribute to the understanding of the Covid-19 epidemic through its focus on uncertainty and risk. Indeed, uncertainty and moral hazard are key to understand how epidemics spread and particularly in the case of a new epidemic burst. Keynes (1921) argues that most individuals would choose a treatment that has been extensively used in the past and has a well-known probability of success, rather than a new one, for which there is little information about its probability of success. Thus it is not granted that the introduction of a new treatment, such as a new vaccine - or any non-compulsory measures - will be used by the population during new epidemics, or whether alternatively, individuals could adopt riskier behaviour even in the presence of good insurance mechanisms.

We shall build a model of individual behaviour in the face of uncertainty conveyed by the new epidemic. The key aspect, beside the modelling of the spread of the disease, is the role of beliefs, uncertainty and learning that drive health and economic behaviour. Those in turn affect the propagation of the disease.

Our framework adapts Adhvaruy's framework (2014) to the Covid-19 crisis, and proposes some extensions. Though the model is calibrated for malaria the intuition behind the behavioural model provided in this article is generalizable to our case. For a given measure/intervention proposed by the public authority, compulsory or not, individuals may or may not adopt it; they might refrain from adopting it even though they have theoretically to pay a penalty. Infected asymptomatic individuals are not observable as infected. On the other hand, it is also true that ordinary symptoms of COVID-19 like fever or cough are also symptomatic of other chronic diseases like flu or colds. If no systematic testing is conducted, then population is facing different forms of uncertainty and will not systematically adopt the measure proposed. A key concept here is the belief that the measure proposed is efficient or not. If individuals believe it is efficient in that it reduces their exposition to the infection risk or it will help to cure them from a possible lethal disease, they will adopt the measure. A key determinant of the beliefs is the observed performance of the measure as it transpires in the daily published statistics on Covid-19 new infections, causalities and other types of epidemiological information released.

Of course, the beliefs evolve over time as new information comes in, and creates a feedback mechanism affecting the adoption rate. Another key aspect which makes the problem even more involved in the case of specific measures like confinement is the duration announced and its credibility. The longer the duration announced, the higher the individual cost of confinement especially for asymptomatic individuals. This heterogeneity enriches considerably the discussion with respect to Adhvaryu (2014). Also, the credibility of public authorities about the parameterization of the measure proposed or imposed is important in the current phase of Covid-19. It is particularly important when the scientific evidence about the real epidemiology of Covid-19 is far from compelling. In this sense, the public authorities also have to learn. In particular, choosing the timing and parameters of interventions (e.g. containment, initiation and duration) given expected epidemiological dynamics will be one issue carefully analysed in this model with respect to the constrained capacity of the hospital system. Most of the countries that did not test the population extensively at the start of the epidemic were next constrained to implement confinement measures to avoid a saturation of the health system and intensive care units.

1.3.2 WP2: Testing model predictions and Calculating the cost-effectiveness of protective measures

Two cohorts of patients will be used during this project in collaboration with REACTing and Santé Publique France: the "cohort of infected patients" (since the first patient treated on 24/01 in Bichat) and the "contact case cohort". These cohorts will be supplemented by data from the sentinel network on cases of Acute Respiratory Infections (ARI) seen in consultation, according to the following definition: sudden onset of fever (or feeling of fever), and respiratory signs (such as coughing, shortness of breath or a feeling of tightness in the chest).

This data will be combined with school closure, transports limitation, public announcements dates on confinement measures and sanitary emergency, data on population movements and Twitter volume peaks on preventive messages. Events will be collected using the LexisNexis interface search of the popular French written press. The dates of the laws and their implementation will be collected via the "Journal Officiel". Data on population movements will be collected through open access data on road traffic provided by CEREMA. Twitter data will be collected through Twitter Search API. The Twitter restriction of 1% (or 10%) of tweets applies to the Twitter Streaming API, and only in the case when the specified filter (query) is general enough to account for more than 1% (or 10%) of all public tweets. To account for externalities and other co-morbidities, we could also make use of data on seasonal flu vaccination or other drugs consumption in French pharmacies, through a partnership signed between the Centre d'économie de la Sorbonne and OpenHealth company.

We will start with an event analysis, where an event will be defined as the first day of the different measures taken to control the epidemic, already mentioned above. We will next estimate simple forms of the model proposed in WP1. We will identify the model without relying solely on time variation or cross-section variation, which could confound many of the effects. The implementation using a fuzzy difference-in-difference identification strategy (De Chaisemartin et al. 2018) will also be a departure from the existing literature in epidemiology. Shocks are possibly serially correlated, which would lead to bias a classical lagged dependent model. We will use a panel corrected standard error procedure allowing for heteroskedasticity, spatial correlation across areas, and for serial correlation of the form of an autoregressive process of order one. The full procedure is described in Adda (2016) and will be augmented to account for uncertainty, learning and undocumented cases.

Lastly, we will perform a cost-benefit analysis, where we will take into account the short and long-run consequences of the policies we evaluate. We will draw on the epidemiological literature for the evaluation of the costs of these diseases, in terms of medication, health care use, and costs. We will also account for the cost of death, which are important for the elderly. The literature calculating the value of a statistical life has provided quite wide-ranging estimates, depending on the method used. Ashenfelter and Greenstone (2004) found a rather low value of about $1.5 million using mandated speed limits. Viscusi and Aldy (2003) review the literature and find values between $5.5 and $7.5 million. Murphy and Topel (2006) use a value of $6.3 million. In this study, we use a range of values between E1.3 and E6 million. We will extend this literature by considering the effect that school closures have on the human capital of children.

1.3.3 WP3: Heterogeneity analysis and guidelines for epidemics preparedness

1.3.3.1 Heterogeneity

It will be difficult to understand which strategies have been most effective without considering the characteristics of each area and population sub-groups. Disentangling these factors is challenging per-se. For example, the seasonal variation over time is an important consideration since variations in temperature or humidity may affect R_0 (Wang et al., 2020; Luo et al., 2020). Another example is that it will be necessary to provide predictions by age groups. The age structure of the French departments could indeed explain that the strategy implemented has been more effective in some departments compared to others. This will make it possible to propose best practices and policies without dogmatic positions for future epidemics. Education and unemployment rate at the department level will be other factors analyzed here. The heterogeneity analysis we propose will concern both the theoretical model and our empirical estimates. In quasi-experimental models, it is easy to cross-check confounding factors with the treatment effect simply by interacting some variables in the models.

1.3.3.2 Guidelines and future epidemics preparedness

One important aspect of this project will be to render very clear our comparisons for policy makers. As Gates (NEJM, 2020) agued, "*improving the way we respond to outbreaks in general has crucial long-term consequences*". We will follow WHO and the World Bank guidelines on costing and cost-effectiveness analysis to produce Covid-19 specific guidelines and generalize them to potential future threats. This will also help us to discuss the external validity of our results. New software, such as Tree-Age, have been developed to render CEA easy to understand. We will use such software to popularize our results with simple graphs.

1.4 Previous works of the coordinator and team (selected)

1.4.1 Academic research

1.4.1.1 Economic activity and Health

1. **J. Adda**, Economic Activity and the Spread of Viral Diseases: Evidence from High Frequency Data. Q J Econ. 131, 891–941 (2016).
2. **J. Adda**, H.-M. von Gaudecker, J. Banks, The Impact of Income Shocks on Health: Evidence from Cohort Data. Journal of the European Economic Association. 7, 1361–1399 (2009).
3. **J. Currie**, B. Grenfell, J. Farrar, Beyond Ebola. Science. 351, 815–816 (2016).
4. M. Brüning, **J. Thuilliez**, Mortality and Macroeconomic Conditions: What Can We Learn From France? *Demography*. **56**, 1747–1764 (2019).
5. **J. Currie**, H. Schwandt, **J. Thuilliez**, Pauvreté, Egalité, Mortalité: mortality (in)equality in France and the United States. *J Popul Econ*. **33**, 197–231 (2020).
6. M. Kuecken, **J. Thuilliez**, M-A Valfort, Disease and Human capital accumulation. Conditionally accepted in *Economic Journal*.

1.4.1.2 Economic epidemiology: Theoretical models and tests applied to other health crises

1. **J. Adda, F. Yarine** "The Health Toll of Import Competition". Forthcoming. *The Economic Journal* (2020).
2. **J. Adda**, Behavior towards health risks: An empirical study using the "Mad Cow" crisis as an experiment. *J Risk Uncertainty*. **35**, 285–305 (2007).
3. **J. Adda**, Preventing the Spread of Antibiotic Resistance. *The American Economic Review P&P*. 2020, 110: 1–6.
4. **R. Boucekkine**, R. Desbordes, H. Latzer, How do epidemics induce behavioral changes? *Journal of Economic Growth*. **14**, 233–a6 (2009).
5. **R. Boucekkine**, B. Diene, T. Azomahou, Growth economics of epidemics: a review of the theory. *Mathematical Population Studies*. **15**, 1–26 (2008).
6. T. Azomahou, **R. Boucekkine**, B. Diene, Hiv/aids and development: a reappraisal of the productivity and factor accumulation effects. *The American Economic Review P&P*. **106**, 472–477 (2016).
7. **R. Boucekkine**, Epidemics from the economic theory viewpoint. *Mathematical Population Studies*. **19**, 1–3 (2012).
8. E. Maskin, C. Monga, **J. Thuilliez**, J.-C. Berthélemy, The economics of malaria control in an age of declining aid. Nat Commun. 10, 1–5 (2019).
9. Y. Dumont, **J. Thuilliez,** Human behaviors: A threat to mosquito control? Mathematical Biosciences. 281, 9–23 (2016).
10. **J. Thuilliez**, Y. Dumont, Public Mosquito Abatement: A Cluster Randomized Experiment. *World Bank Econ Rev*. **33**, 479–497 (2019).

1.4.2 Media (selected)

1. L'Express 11 March 2020 – Les Echos 17 March 2020 – Le Figaro 1 March 2020, covering research by **Jérôme Adda** on the efficiency of quarantines on the spread of the Corona (Covid-19) virus.
2. CNRS-Le Journal 17 March 2020 - French Journal covering research by **Josselin Thuilliez** on the economics of epidemics.
3. VoxEu CEPR Policy Portal - Stigler Center at the University of Chicago, RFI, and LeMonde, "When Social Policy Saves Lives" covering research by **Josselin Thuilliez** with Janet Currie and Hannes Schwandt.

1.5 Tasks schedule, deliverables and milestones: Gantt diagrams

	Timing diagram (months)					
	Year 1				Year 2	
	3	6	9	12	15	18
WP0 Project coordination						
Project reports	✪	☺		☺		☆
Workshops/ Meetings	X		X		X	
WP1 - Model						
Task 1.1						
Task 1.2						
Task 1.3						
WP2 - Empirics						
Task 2.1						
Task 2.2						
Task 2.3						
WP3 - Recommendations						
Task 3.1						
Task 3.2						
Task 3.3						
Feedbacks from external experts	X		X		X	
Deliverables Milestones		**D1.1.**		**D1.2.**	**D1.3.**	
		D2.1.		**D2.2.**	**D2.3.**	
				D3.1.	**D3.2.**	**D3.3.**

✪ : *Consortium agreement* ☺ : *6 month-progress report and Mid-term progress report* ☆: *Final report + expenses summary*

***Table 1:** Synthetic Schedule of tasks and deliverable*

Task	***Deliverables***	***Leader***	***Date of delivery***
T1.1. Preliminary modelling steps	**D1.1.** Literature review on Covid-19 diffusion models	J Thuilliez	M6
T1.2. Modelling	**D1.2.** A diffusion model including behaviours, uncertainty and learning	R Boucekkine	M12
T1.3. Calibration	**D1.3.** Quantification of the role of undocumented infections in France in transmission	R Boucekkine & J Thuilliez	M15
T2.1. Data management	**D2.1.** Final high frequency database combining events with epidemiological data	J Thuilliez	M6
T2.2. Econometric Model	**D2.2.** Treatment effect estimates of the 3 measures.	J Adda	M12
T2.3. Costing and CEA	**D2.3.** Costing and comparative cost-effectiveness report	J Adda & J Thuilliez	M15
T3.1. Heterogeneity analysis	**D3.1.** Refine conclusions by sub-groups	J Adda & J Thuilliez	M12
T3.2. Publications & Dissemination	**D3.2.** Meeting with public authorities and networks / Presentation of results	J Adda & R Boucekkine & J Thuilliez	M15
T3.3. Guidelines and policy recommendations	**D3.3.** Guidelines to foster and facilitate the preparation of future epidemics both within and across countries.	J Thuilliez	M18

***Table 2:** Deliverables Milestones*

2 Team

2.1 Coordinator : Josselin THUILLIEZ

Josselin Thuilliez (37 yo, PhD defense in December 2009, Habilitation in 2015). I am a Researcher at CNRS and the Director of the Research Group in Development Economics (https://twitter.com/SorbonneDevEcon) and member of the restricted management board of the Centre d'Economie de la Sorbonne (http://centredeconomiesorbonne.univ-paris1.fr/). The center is about 95 researchers and 120 doctoral students. I am also a member of the steering committees of Aviesan Sud and Reacting https://reacting.inserm.fr. My work analyzes the effect of infectious diseases on economics outcomes and human capital and conversely the effect of economic activity on health and trends in inequality in cause-specific mortality. I also built economic epidemiological models and examined the trade-off between prevention and treatments. One of my last works has shown that epidemiological cycles may fit with innovation cycles. My work has thus always focused on the interactions between epidemiology, biostatistics and economics from both empirical and theoretical perspectives. I have led population–based intervention trials to study human behaviors and nudges in response to epidemiological threats in order to provide public policies recommendations. Examples of applications on epidemics include evaluations of ARS interventions in La Réunion between the Chikungunya crisis in 2006 and the Dengue epidemics in 2017. I now intend to apply this expertise to a public health urgency. I have been contacted by the CEMAC to provide recommendations on the Covid-19 outbreak.

2.2 Partners: A transdisciplinary team of high quality and complementarity

2.2.1 Jérôme ADDA (Bocconi University, Milan).

Jérôme Adda earned his Ph.D in Economics at the University of Paris (Sorbonne) after studying biology at AgroParisTech and economics and statistics at ENSAE in Paris. He is a professor of Economics at Bocconi since 2014. Prior to that he was a professor at the European University Institute (Florence), as well as a Professor at University College London. He has been a visiting Associate Professor at the economics department at Berkeley in 2006-07. He was a managing editor for the Review of Economic Studies, 2013-2017. His research interests include Health Economics, Labor Economics and Macroeconomics. His main contributions have been on the effect of public policies on health behavior, the links between income and health, the role of human capital on career choices over the life cycle. Many of his papers have been published in the top journals in economics as well as in other disciplines.

2.2.2 Raouf BOUCEKKINE (Aix-Marseille School of Economics & IMéRA)

Raouf Boucekkine is professor of Economics at Aix-Marseille University since 2011, director of the Institute for Advanced Study at Aix-Marseille (IMéRA), and honorary senior member of the Institut Universitaire de France. He was professor at UCLouvain, co-director of the Center of Operations Research and Econometrics (CORE), and part-time research professor at Glasgow University after an initial career at Carlos III Universidad at Madrid. He was president of ASSET (Association of Southern European Economic Theorists), 2015-2017. Raouf Boucekkine is member of the research council of several institutions, including IRD (*Institut de Recherche en Développement*). His main research areas are economic growth and development theory, mathematical and economic demography and operational research, to which he has extensively contributed in the three last decades. His interest in epidemics traces back to his cooperation work at DRCongo, 2007-2015. Since then, he has written extensively on how epidemics induce behavioral changes and on the economic consequences of large-scale epidemics in leading economic and interdisciplinary journals.

2.3 External experts

Four external experts from different fields have been added in the governance of the project to receive feedbacks on our results and model. Their role will be limited to provide technical advice or help to spread our results towards policy makers and civil society.

2.3.1 External advisor in health economics: Janet CURRIE (Princeton University).

Janet Currie is the Henry Putnam Professor of Economics and Public Affairs at Princeton University and the Co-director of Princeton's Center for Health and Wellbeing. She also co-directs the Program on Families and Children at the National Bureau of Economic Research. She is the President of the

American Society of Health Economics, has served as the Vice President of the American Economics Association, and is a member of the National Academy of Sciences, the National Academy of Medicine, and of the American Academy of Art and Sciences. She is a Fellow of the American Academy of Political and Social Science, the Society of Labor Economists, and of the Econometric Society, and has honorary degrees from the University of Lyon and the University of Zurich. She was named a Nomis Distinguished Scientist in 2018. She has served on the Board of Reviewing Editors of Science, as the Editor of the Journal of Economic Literature, and on the editorial boards of many other journals. Her current research focuses on socioeconomic differences in health and access to health care, environmental threats to health.

2.3.2 External advisor on policy implications: Eric D'ORTENZIO (REACTing)

REACTing brings together multidisciplinary and multi-institutional teams working on emerging infectious diseases, not only COVID -19 but also other emerging diseases. Its mission is to prepare and coordinate French research to prevent and control epidemics. The Ministry of Higher Education, Research and Innovation has entrusted REACTing with the responsibility of coordinating French research on the new coronavirus. Thus, from the very first days of the epidemic, REACTing has been mobilized. The teams involved in the coronavirus were able to benefit from seed funding to launch their work, allocated by the REACTing COVID-19 Scientific Council. Finally, 20 projects were selected, on 4 main themes: epidemiology; clinical research, diagnosis and therapy; fundamental research; human and social sciences. REACTing is one of the privileged interlocutors of the public authorities in this crisis and facilitates a collective advocacy of research actors Research must be part of the response to an epidemic. REACTing also enables researchers and industrialists to be put in touch with each other on issues such as access to samples, treatments, diagnosis, etc. In the longer term, it contributes to the international community's reflection on the best response to these epidemic threats. Eric D'ortenzio is the scientific coordinator of Reacting and will help us to work collaboratively and in complement with other teams mobilized on the COVID-19 pandemic. We want to be connected to the REACTing network and policy makers in order to adapt our model and estimates to the needs over time. This is, to our opinion, indispensable and disconnected from other considerations (potential conflict of interest) considering the gravity of the situation and the extremely active role played by REACTing in the crisis. Eric d'Ortenzio accepted to participate under this condition and will not be a formal partner of this project but only an external advisor. We want to be fully transparent on this point.

2.3.3 External advisors on cohorts: Harold NOEL & Daniel LEVY-BRUHL (Santé Publique France)

Since the emergence of this new disease, COVID-19, in January 2020, all public health agents in France have been mobilized and the complementary nature of their work is fully expressed in the service of the population. Their action consists of monitoring and understanding the dynamics of this epidemic, anticipating different scenarios and implementing actions to prevent and limit the transmission of this virus on the national territory. As knowledge about the characteristics of this disease and virus evolves very rapidly day after day, the mobilization is total in coordination with the French (Ministry of Solidarity and Health, Regional Health Agencies, etc.) and international (World Health Organization, European Centre for Disease Control and Prevention) authorities. Harold Noel and Daniel Levy Bruhl are medical epidemiologist at Santé Publique France and will help us to access and understand epidemiological data.

2.4 How the research team will work as a team? (who does what and why?)

The team we propose to build is of high quality and is very complementary. In economics, Jérôme Adda has published extensively in health economics and epidemiology and has developed models of individual behavior that can enrich current models of epidemics. Raouf Boucekkine is an expert in behavioral modelling. Janet Currie is one of the best experts in the world in health economics and will provide an external view based on US experience on this crisis. In public and global health, our work will build on REACTing's expertise and the data will come from Santé Publique France. Reaching an extremely fine integration of economics and epidemiology should open new avenues for research. The project will strengthen Josselin Thuilliez's transdisciplinary orientation at CNRS, notably for a Research Director position and serve as a catalyst in this process.

Josselin Thuilliez will be involved more than Raouf Boucekkine and Jérôme Adda as he will coordinate the project, look for the data, centralize external feedbacks on the results and ensure that the outcomes of the project are shared with REACTing and policy makers. However, the load of scientific tasks will be similar for the three of us. Josselin Thuilliez and Raouf Boucekkine knows each other for a long time despite no previous collaborations. Jérôme Adda and Raouf Boucekkine made their PhDs together and co-published together early in their career. Because the team is limited, meetings and calls should be very efficient. The three researchers live in France or Italy and can travel easily to Paris, Milan or Marseille.

3 Impact of the proposal

Shortly after the epidemic crisis, the population, the media, public health services and policy makers will wait for critical evaluations on the management of the crisis. Elements of comparison of the strategies implemented will therefore be necessary on the short term. As a result, without this project on cost-effectiveness, there will be a knowledge gap. It now seems clear that the different countries have not adopted exactly the same strategies. The Korean and Japanese strategies, for example, have been very different from those of Italy, Spain or France. Some seem more effective than others but providing robust answer to this question is challenging. Our project will be able to compare such strategies - combined with the dynamics of the epidemic – and will provide extremely solid evidence-based arguments. Our analyses will be replicable and all materials (data and programs) will be provided freely on our websites. Combined with other sociological or anthropological analyses that will be produced elsewhere, it will be interesting to see if the most cost-effective strategy could be culturally acceptable and legally feasible in France.

4 Budget

The proposed budget of 187 133, 76 euros has been calculated to cover the concrete expenses related to the project. A powerful computer will be required for the calibration of the model and empirical tests. We will also need one post-doctoral fellow to support us in modelling and data analysis (18 months). Finally, we will need a research assistant for a shorter period of time to make a literature survey, prepare and merge the databases (12 months), collect data on costs and conduct some interviews for this purpose. These two junior researchers will need laptops as they will have to travel occasionally between Paris, Bocconi and Marseille. The budget is fully detailed in the technical document provided on ANR submission website.

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