



# Perspectives on the Economics of the Environment in the Shadow of Coronavirus

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## 1 COVID-19 and Its Implications for Environmental Economics

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The *Environmental and Resource Economics* special issue “Economics of the Environment in the Shadow of Coronavirus” comes at a hugely critical time for environmental economists and policy makers alike. We are in a situation of significant social change, a change that could potentially lay the foundation for mankind’s future in the years to come.

As part of this special issue, ERE is trialling a novel, experimental form of article, drawing together short, focussed pieces from a wide group of authors addressing the plethora of issues which such a fundamental challenge as the coronavirus pandemic generates. These provide critical and reflective perspectives on the environmental, socio-economic and policy paths that may be taken in the near and further future—strategies that could lead mankind either on roads to a much more sustainable development, or along paths that could bring about more instability, inequality and further environmental pressures. This innovative article combines short, policy-relevant and less technical papers that deal with specific aspects and provide clear recommendations for policy makers and suggestions for future research alike. The target audiences are policy makers and companies, but also researchers who want quick yet sufficiently detailed knowledge about particular analyses relating to COVID-19 and issues in environmental economics. We hope that the articles contained within this Perspectives collection provide the necessary information for policy makers to take wise decisions for our future, and for researchers the knowledge to help guide policy makers in their decisions.

### **Pushing the Boundaries on Spaceship Earth**

Humankind has been very fortunate to have lived through a period of sustained economic growth pretty much since the agricultural revolution, with especially high rates of growth starting from the second half of the twentieth century. This economic progress has allowed us to make unprecedented improvements in consumption, in health, in education and in addressing inequality. Many of us have been fortunate enough to have lived without a war for the past 70 years, which is widely believed to be due to the development of international

institutions and a deepening of international trade that led to widespread cooperation and, with it, it brought a new era of global stability.

At the same time, the rapid increases in humankind's population, from around 2 billion in 1930 to 7.8 billion in 2020, coupled with an increase in real-world GDP by a factor of roughly 40 during the same period, have led mankind to progressively push closer to the boundaries of planet Earth. To provide additional food for the surge in population, agricultural land use has increased by 30%; to provide goods and services for the surge in demand, the material footprint of our production increased by an estimated factor of 40; and to provide energy for our lifestyles, our use of non-renewable and polluting resources (coal, oil, gas) increased by a factor of 8. This increase in consumption coupled with a similar increase in input use has transformed the face of the planet Earth and has given rise to unwanted side effects and new challenges.

Some of these challenges are well known, such as local and global pollution, problems of waste and certainly climate change. Another, often neglected challenge, has been a consistent pressure on biodiversity due to our increase in land use. A mixture of burgeoning population and increasing resource use that carved deeply in nature's pristine areas has led to species conflict manifested not only in the rapid loss of other species, but also in a much ignored yet increasingly visible negative feedback in the form of viral crossovers (Smith et al. 2014). The linkages between economic development, viral crossovers in the form of communicable diseases and environmental issues in particular have, up to now, seen little attention from environmental economists.

### **A New Global Threat Enters the Stage**

As we have now seen, it was worryingly neglectful on our part to not consider these feedbacks more seriously. The greater interconnectedness via global trade and international migration, air travel for both tourism and business purposes, as well as the ongoing growth of large city hubs, have made it easy for communicable diseases to transcend local spaces and quickly make their appearance in even remote corners of the world. While the Black Death and the Spanish Flu have been among the worst communicable disease outbreaks in recent history, in late 2019 a new virus was detected in Wuhan, China. Identified as a new member of the coronavirus family and subsequently called COVID-19, within the course of half a year this virus has spread out from the Huanan wet market in Wuhan across the whole world. Even inhabitants from otherwise remote places such as villages in Timbuktu, the Korubo and Yanomami tribes of the Amazon, the Navajo Nation of North America and the Arctic Inuit have already tested positive for COVID-19.

Due to initial uncertainty surrounding both the impact of COVID-19 and its spread through society, many policy makers quickly decided to shut down interactions among individuals by restricting local, national and international mobility. These "lockdowns" had pervasive impacts on economic activity across the globe, with significant reductions in production, increases in unemployment, falls in international migration, diminished levels of international trade, significant increases in bankruptcy filings and large ripple effects down supply chains. Relative impacts between developed and developing countries are still very much developing. Globally, herd immunity is expected to take some time to develop if indeed it ever does. A vaccine that has the potential to be potent and widely available may need at least another 1 or 2 years for development and broad deployment. Some countries are already close to a second wave—this pandemic is here to stay for a while. The question is as to how we shall deal with it. While reducing physical contacts to "flatten the curve" of disease and death has been the preferred policy to slow down the spread of the

virus in order to keep serious cases below hospital capacities, consequent impacts upon the economy, society and increasingly environment have arisen. The papers curated within this Perspectives collection provide a valuable early insight into these trends and their future management.

### **Unclear Implications for the Environment: An Overview of the Perspectives Collection**

Environmentalists were especially euphoric at the early stages of the lockdowns. Cazarro and co-authors estimate the impact of the COVID-19 crisis for Europe and its trade-related spillovers to the rest of the world and find significant decreases in major environmental pollutants. There is preliminary evidence that this helped both to reduce the effect of the COVID-19 virus, and lower long-term pollution levels may also help individuals to cope with the virus (Peña-Lévano and Escalante). The resulting clear skies, improvements in local water quality, reductions in noise and air pollution as well as substantial numbers of employees working in home offices have raised the hope that mankind is ushering into a new era of a transformed society with reduced pollution and lowered environmental impacts. These hopes were, however, short-lived (McCloskey and Heymann 2020). Not only have, so far at least, all countries that have (mostly) overcome the first wave returned to business as usual, but companies have also used the opportunity to lobby for relaxed emission standards, to increase subsidies or receive financial aid and, therefore, been able to quickly return to the pre-COVID-19 status quo. Side effects are that, already in the short run, many initial improvements in environmental quality succumbed to a relaxation of environmental regulations and a catching-up process that brings countries back to their original economic growth levels. There are early signs that this rebound effect is due to reductions in public transport, increased use of ICT and expected changes in land use leading to levels of pollution that may even rise above pre-COVID-19 levels (Freire-González and Vivanco). Cojoianu and co-authors show that the rebound effect may have been partly financed by the bonds bought through the European Central Bank's Pandemic Emergency Purchase Programme (PEPP) in response to COVID-19, as they provide empirical evidence that these bonds are more likely to be issued by carbon-intensive companies, or those that lobby more for carbon-intensive sectors. Lopez-Feldman and co-authors discuss the environmental impacts from the COVID-19 crisis with a focus on Latin America, especially deforestation and air pollution, and show that a rebound effect is already happening and will potentially worsen. In addition, Xepapadeas shows that COVID-19 had not only a short-run negative impact on comprehensive wealth but may also lead to a long-run worsening of sustainability. Shehabi argues that for oil exporting countries, the current crisis increases the opportunity cost of moving to greener alternatives and that, for some regions, stimuli packages may reallocate funds away from green investments.

In contrast to the results presented above, there is a larger movement that argues that this crisis also bears unexpected opportunities. As has often been argued, structural breaks, in this case in the form of COVID-19, are game-changing opportunities that allow policies to be focused on long-term commitments to achieve desired climate targets. The newer recent social momentums, like Friday for Futures, or the policy-pushed New Green Deals, or the focus that the IPCC has laid on 1.5 °C warming, have placed environmental issues at the forefront of many discussions and potential policy changes. The calls for green stimuli, i.e. COVID-19 rescue packages that focus on a green transition, have been astonishing. It is precisely these green stimuli that may turn out to be long-term game changer that environmentalists

were advocating for. It is at this point where the contributions selected for this special issue provide first thoughts, first answers and first suggestions for policy makers from the cutting-edge research of environmental economists. In particular, the arguments forwarded support a strengthened focus on economic recovery that, first and foremost, should not undermine the green transition, while also, if possible, provide measures to advance the green transition. The articles then discuss the approaches and potential difficulties that policy makers will be faced with when being confronted with the precise means to implement these green recoveries.

### **Approaches and Difficulties when Designing a Post-COVID-19 Green Transition**

As a first step, due to unprecedented levels of unemployment in places such as the USA and significant contractions to economic growth in most countries of the world, an important consideration is that the focus of the stimuli packages should be the economic recovery, i.e. to predominantly deal with the direct impact of the lockdowns on economic activity. Once the virus is contained and the short-run recoveries are under way, then it is, however, important to quickly integrate longer-term factors into policy making (Borghesi and co-authors). Here, it is vital that, in contrast to the stimuli in the aftermath of the 2008 financial crisis, policy makers also address inequality (Koundouri and co-authors). A more specific focus on furthering a green transition should only be placed once a certain level of economic recovery has been achieved. This is especially vital as the disruptions to supply chains can have fundamental and unpredictable consequences, as often even companies themselves are not fully aware of their complete supply chains. Cazarro and co-authors estimate some of the impacts of these trade-related supply chains and, for example, show that the European demand changes due to COVID-19 have, in total, larger impacts on the rest of the world than on Europe itself.

Requirements for successful green stimuli are that these policies are implemented in a clear and transparent manner (Rickels and Peterson). In this regard, Ing and Nicolai argue that companies are likely to prefer stimuli packages that are tight to some environmental efforts rather than to new environmental regulations. On the converse, linking stimuli with environmental efforts is more costly for policy makers and likely to be less efficient. Several of the articles in this special issue draw particular attention to the fact that the green stimuli are not enough to successfully further a green transition. What is also necessary is to couple this with a price on carbon and a restructuring of the subsidies paying attention to both the green and fossil industry (Gawel and Lehmann). A stronger social contract with a higher degree of citizen involvement will furthermore help gain public support but also strengthen social norms and thus decentralized internalization of externalities.

Lopez-Feldman and co-authors discuss the policy responses to COVID-19 with a focus on Latin America and argue that, to minimize the likely rebound effect, policies need to be much better coordinated. We have seen that international cooperation quickly breaks down when a crisis looms, so that it would make sense to design international institutions with binding laws and penalties in case of non-compliance.

### **New Implications for Research**

What we have seen so far is that COVID-19 has the potential to become a game changer when it comes to combining stimulus packages with the green transition. That this is a sensible strategy derives from the observation that restricting global warming to 1.5 °C requires efforts that go beyond what countries were willing to do so far, and that the stimuli provide the needed opportunity. While the articles contained in this special issue already provide many reasons for policy makers to push for green stimuli, they also clearly point out the difficulties associated with implementing these well.

Some articles in this special issue also show limitations of current policies or research approaches. For example, Borghesi and co-authors discuss that during the COVID-19 crisis the Market Stability Reserve helped to stabilize the EU ETS price, but imperfectly. It is, therefore, important to consider ways in which these imperfections can be redesigned. On a different topic, Laude explains how the COVID-19 crisis has brought to light both advantages and problems with having local, short supply chains for food, and that there is a substantial lack of research directed towards the impact of crises on the agricultural sector. Another example is a more cautionary tale and deals with the COVID-19 cases data. Here, Cohen and co-authors show very clearly that researchers must be careful with simply using these data as there are many problems in the data collection processes, which differ across countries and also time.

As a final remark, we would like to observe that this special issue not only comes at a very turbulent time for mankind in general, but it also comes at a special time for environmental economists in particular. The COVID-19 crisis gives the opportunity to invest significant amounts of money towards aiding the green transition, and the widespread public support is there. We need to now be able to advise policy makers on efficient, reasonable and relevant policies that they may implement as part of the green stimuli packages. However, these policies also need to be well structured and grounded in good research. The peer-reviewed articles in this special issue provide suggestions and articles with these features and will thus, hopefully, serve as a first benchmark in this endeavour.

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## 2 What do the European COVID-19 Final Demand Changes Imply for Resource Use and Environmental Pressure?

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### 1. Introduction

In this paper, we use a multisectoral and multiregional model of the world economy to evaluate the short-term effects that the COVID-19 crisis may have on environmental pressures and resource consumption (measured in terms of water, air emissions and materials extraction). Specifically, we focus on the relationship between current and forecast changes in

demand and mobility patterns in the EU27 + UK for 2020 and its effect on global resources through global supply chains. This integrated analysis could answer urgent research questions: What are the short-term impacts on emissions and resource consumption of the current and predicted declines in final demand? Do the impacts differ among environmental pressures? How elastic are environmental responses to demand drops? On the basis of these short-term responses, what is the relationship between economic growth and environmental pressure? Do these effects go beyond European countries through global supply chains?

## 2. Computations and Results

In order to evaluate the short-term effects of changes in aggregated sectoral consumption and demand on environmental pressures, and their diffusion through global supply chains, we develop an environmentally extended multiregional input–output model (see Miller and Blair 2009, or recently Hubacek et al. 2016; Guan et al. 2020), using the EXIOBASE 3.7 database (Stadler et al. 2019). We focus on water consumption (blue and green), mineral extraction and emissions ( $\text{CO}_{2\text{eq}}$ , SO<sub>x</sub>, NO<sub>x</sub>, NH<sub>3</sub> and CO). We rely on the estimates from the Eurostat Spring Forecast (EC 2020a) which estimate for the EU27 + UK a change of –12% in consumer expenditure, 0.8% in government expenditure and –15.3% in investment for 2020.<sup>1</sup> Sectoral changes in private consumption are estimated based on EC (2020b) and OECD (2020), assuming different sectoral sensitivities to the COVID-19 crisis. Specific details and the complete matching process can be found in online Appendix. Our results are as follows:

Figure 1 shows the EU27 + UK (light blue bars) and global (dark blue bars) change in different environmental pressures associated with the shock to final demand and household mobility in EU27 + UK, as a consequence of the 2020 COVID-19 lockdown. The expected percentage impacts are much larger in the EU27 + UK, as the simulation of final demand and mobility directly affects these countries, given the high level of intra-EU dependence. However, the European lockdown also impacts foreign resources due to the interlinkages throughout the production chain. In general, the largest decline happens to gas emissions, both in EU27 + UK and worldwide. The average 7.8% fall in the aggregate of the three cited components of European final demand (households, government expenditure and investment, representing a 6.9% fall in total final demand) that globally represents a 1.6% decline, would involve a 0.4% decline in global water consumption and 1.3% in mineral extraction. The global fall in emissions from the slowdown in economic activity and European mobility restrictions would be around 1.2% ( $\text{CO}_{2\text{eq}}$ ). Comparing the effect in EU27 + UK with the global impact, the percentage change runs from four times larger in Europe, in the case of water, to 14 times greater for  $\text{CO}_{2\text{eq}}$  emissions. We find a drop of more than 5% for mineral extraction and emissions in EU27 + UK.

Emissions are reduced, and by more than water and minerals. Also, even when no direct electricity demand change is assumed, given the reduction in sector activity, indirect energy demand diminishes and so do emissions. Specifically, our model indicates that the production and supply of electricity explain approximately 24% of the greenhouse emissions fall worldwide and 21% in the EU27 + UK. In line with the results of Le Quéré

<sup>1</sup> These forecasts could vary according to the evolution of the pandemic, which is why we are especially interested in the sensitivity of resources uses and environmental pressures to changes in final demands.

et al. (2020), our estimates confirm that the reduction of emissions associated with private mobility restrictions would account for 30%<sup>2</sup> of the total fall in emissions in Europe, whereas the reduction linked to air travel reaches 10.5%. Worldwide, these drops would be 18% and 9%, respectively. The European lockdown affects the iron and steel industries globally, representing 7% of the global fall in greenhouse emissions.

Several other resources are less dependent on the most-affected sectors. The supply chain of food clearly depends on the supply of water. It is difficult to estimate the reductions in the HORECA sector based on the available data. That sector, as well as many others that indirectly require these natural factors throughout their supply chains, exhibits significant reductions in resource use. Our data show that the largest decline in water consumption (both blue and green) is associated with the primary sectors, which, as expected, experience slight negative growth rates around  $-0.3\%$ , given the relatively stable and anti-cyclical nature of food demand.

Analysing the changes induced by the different components of final demand,<sup>3</sup> the decrease in household consumption and investment drives environmental impacts to a lesser extent. Worldwide, the fall in investment mainly affects environmental impacts (except for water consumption). Reductions in investment have a larger role in reducing emissions in small countries like Croatia and Malta, and also in Eastern Europe, such as in Hungary, Latvia, and Slovenia. In the EU27 + UK, household consumption is the most significant element of final demand driving the changes in environmental pressures (with the exception of mineral extraction), explaining 45% of the European greenhouse gas emissions fall. As for minerals, their strong dependency on gross capital formation destinations, such as construction, manufacture of machinery and equipment, computer and related activities, explains that the 2.7% fall in investment worldwide ( $-15.3\%$  in EU27 + UK) triggers a 1.1% drop in their global extraction ( $-4.6\%$  in Europe).

These changes are distinct by country, with implications for different areas of the world. The intra-EU trade is revealed to be highly important, showing that the main changes occur within the EU27 + UK countries (even if the individual shock of a given country is not so significant). Figure 2 displays the percentage falls in  $\text{CO}_{2\text{eq}}$ ,  $\text{SO}_x$ ,  $\text{NO}_x$  and  $\text{NH}_3$  emissions by EU27 + UK country. According to the projected changes, the greatest cuts are expected in  $\text{CO}_{2\text{eq}}$  emissions.

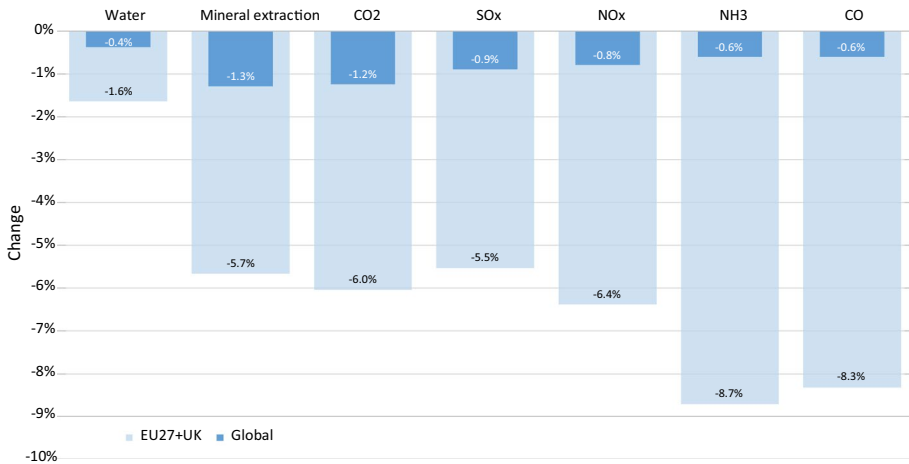
Almost a quarter of the estimated reduction in  $\text{CO}_{2\text{eq}}$  emissions occur in Germany (Figure SI 2). The reductions in  $\text{CO}_{2\text{eq}}$  emissions in smaller economies, such as Ireland, Austria, Greece, and Cyprus exhibit the largest percentage falls. Reductions in Mediterranean and Eastern countries are high, mainly in large countries like France, Romania, Portugal, and Spain.

We note the potential reduction in  $\text{NO}_x$  emissions as a consequence of the production shutdown in France and Germany (as it occurs with  $\text{NH}_3$  emissions), but the largest percentage drops occur in smaller economies, like Austria, Ireland, and Greece. France also shows the highest reductions in  $\text{SO}_x$  emissions, together with Poland and Germany, Ireland and smaller countries.

Our model also allows us to evaluate how the reduction in the EU27 + UK demand modifies the pressures on environmental resources outside Europe, by considering transmission effects through global supply chains. The largest percentage reduction in domestic impacts

<sup>2</sup> In alternative scenarios,  $\text{CO}_{2\text{eq}}$  emissions due to the restriction of private mobility would range from  $-28$  to  $-39\%$  in total  $\text{CO}_{2\text{eq}}$  emission declines in Europe and worldwide from  $-14$  to  $-22\%$ .

<sup>3</sup> See Figure SI 1 in appendix for detail of the impact of the different demand categories.



**Fig. 1** Global (dark blue) and EU27 + UK (light blue) environmental impact changes related to the total final demand and household mobility shocks during the lockdown. *Source:* own elaboration based on EXIOBASE 3.7 database and Spring forecast 2020 (EC 2020a). (Color figure online)

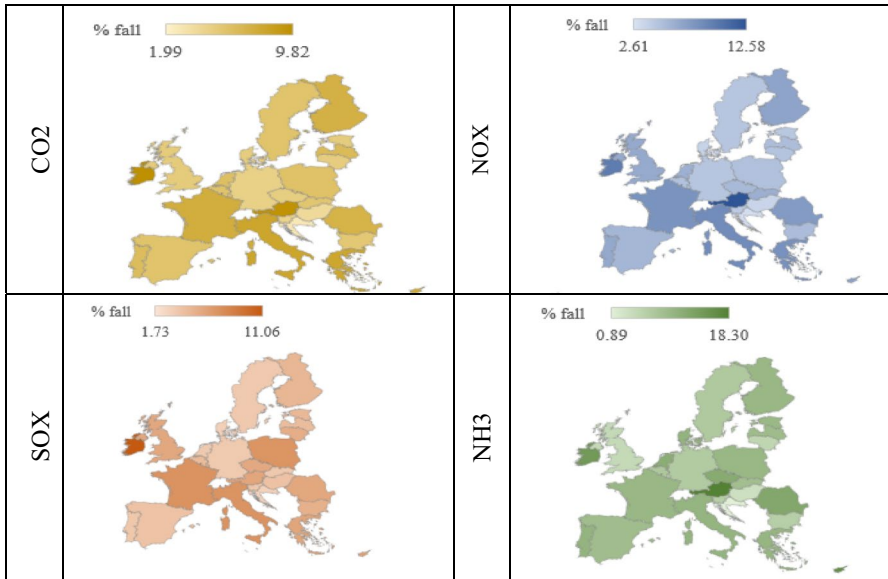
arising from the lockdown and subsequent situations in Europe occurs in non-European developed countries, with smaller effects in developing economies (Fig. 3).

We find considerable indirect declines in mineral extraction (larger than 4%) and gas emissions (between  $-0.8$  and  $-2.1\%$ ) in the USA and Japan. These are mostly associated with linkages with Italy, Germany, UK and France. In countries such as China, Brazil and India, none of the falls in environmental pressure exceeds 0.6% (with the exception of a 1% fall in mineral extraction in India). Again, we find important declines related to the commercial linkages of developing countries with European powers, such as France, Germany and the UK, and with other European countries severely affected by the pandemic (and thus their final demand), such as Italy and Spain. These results support the statements of Baldwin and Mauro (2020) on the existence of a “supply-chain contagion” related to the COVID-19 lockdown (in Europe in this study). However, the “environmental supply-chain contagion” is modest outside the EU27 + UK.

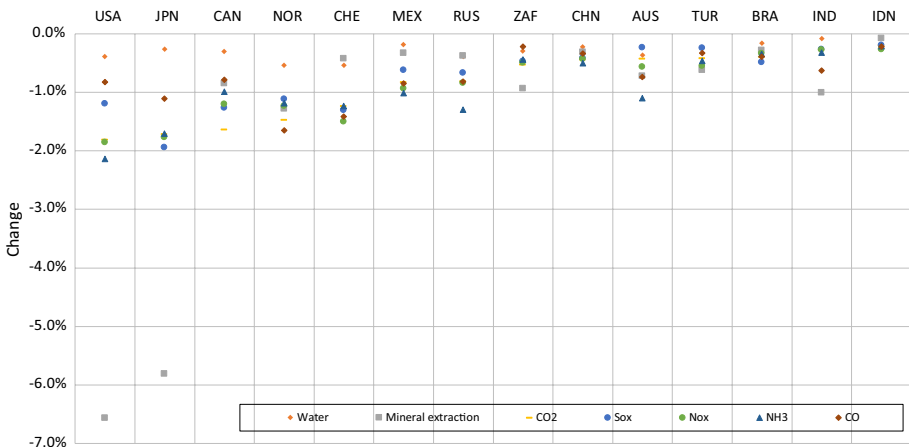
## Conclusions

One of the main implications of our work is that the changes occurring in 2020 in the EU27 + UK are not, in and of themselves, able to sufficiently reduce global environmental pressures. These changes have entailed reductions in domestic activities, which have also affected other EU partners, given the high level of intra-EU trade. Although some of those changes do not have strong impacts on domestic environmental pressures, transport restrictions within the EU have notably reduced CO<sub>2eq</sub> emissions and, even more positively, reduced other pollution-induced health damage. Changes outside Europe occur due to spillover effects, being relatively more notable for minerals. However, the demand for goods, which ultimately depends on resource use and pressures external to the EU27 + UK, has not fallen so clearly, and the lion’s share of the pressures has not been reduced as much as final demand. In short, we have shown the importance of intersectoral relationships and multipliers to understand demand changes, which are uncertain along 2020, and which we





**Fig. 2** Emission percentage changes in EU27+UK countries generated by the shocks to EU27+UK total final demand and private mobility during the lockdown. *Source:* own elaboration based on EXIOBASE 3.7 database and Spring forecast 2020 (EC 2020a). (Color figure online)



**Fig. 3** Environmental impact changes in countries outside EU27+UK generated by the shocks to EU27+UK total final demand during the lockdown. *Source:* own elaboration based on EXIOBASE 3.7 database and Spring forecast 2020 (EC 2020a)

do not expect to be repeated soon unless dramatic changes in private transport, travel and technological changes to green the economies occur.

Future work can add to these variables the specific impacts to the supply chains, and hence on resources, of the variety of recovery measures that are currently under discussion.

In the European context, these concerns are strongly associated with a *European Green Deal*, with investment in renewables and with digitization.

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## 3 The European Green Deal, Sustainability, Carbon Neutrality and COVID-19

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On 19 December 2019, the European Commission presented The European Green Deal (EGD 2019)—a roadmap for making the EU’s economy sustainable by turning climate and environmental challenges into opportunities across all policy areas, and making the transition just and inclusive for all. The central objective of the EGD is to attain a climate neutral EU by 2050, which means that the EU will aim to reach net-zero greenhouse gas emissions by that year. The actions required to reach this target include decarbonizing the energy sector, which accounts for more than 75% of the EU’s greenhouse gas emissions; renovating buildings to help reduce energy use which currently accounts for 40% of the EU’s energy consumption; supporting industry so it can innovate and become a global leader in the green economy; and promoting cleaner transport, which constitutes an important source of the EU’s emissions.<sup>5</sup>

<sup>4</sup> I would like to thank Elettra Agliardi and Joan Stefan and an anonymous referee for valuable comments on an earlier draft of this paper.

<sup>5</sup> With regard to carbon leakage, the EGD (2019, p. 6) states that: “Should differences in levels of ambition worldwide persist, as the EU increases its climate ambition, the Commission will propose a carbon border adjustment mechanism, for selected sectors, to reduce the risk of carbon leakage.”

In terms of resources needed, at least €1 trillion (European Commission 2020) are projected to be necessary over the next decade according to the European Commission, with sources including the EU budget, national budgets and the private sector. Furthermore, the EGD encompasses the so-called just transition mechanism whose objective is to help reduce the negative impacts on coal mines or steel factories associated with decarbonization.

The roadmap for the EGD includes actions related to climate ambition, clean energy, circular economy, smart mobility, greening the common agricultural policy, preserving and protecting biodiversity, and attaining a toxic-free environment and was planned to commence during the spring of 2020.

The COVID-19 pandemic which appeared in Europe in early 2020, and the containment measures taken in order to control the pandemic and reduce the transmissibility of the virus—the  $R_0$ <sup>6</sup>—below 1, have had a profound impact on the economy.<sup>7</sup> In terms of macroeconomics, the COVID-19 shock on the economy can be regarded as a Keynesian supply shock in a multi-sector economy which triggers shortages in aggregate demand larger than the shocks themselves (Guerrieri et al. 2020). Policies to deal with immediate impacts of COVID-19 are aimed at a fast recovery from the recession, so that the policies are designed and implemented in a short-run context.

The question which this note seeks to explore is whether the policies undertaken as a response to COVID-19 could have long-run implications—positive or negative—in terms of sustainability and the objective of carbon neutrality.

Arrow et al. (2012) state that economic development is sustained at a given point in time if intergenerational *well-being* is non-declining at this point in time. Intergenerational well-being is non-declining if the *comprehensive wealth* of the economy is non-declining. Comprehensive wealth is the value of the assets<sup>8</sup> of an economy, with the asset base or productive base consisting of reproducible capital, natural capital, human capital and health capital. Social capital can also be included in the productive base. Thus, the issue of sustainability can be analysed in terms of non-declining comprehensive wealth or productive base.<sup>9</sup>

The implications of the COVID-19 shock on sustainability should therefore be examined in the context of its impacts on the productive base of an economy. The impact of COVID-19 on the productive base is realized directly through morbidity and mortality and indirectly through the recession that is induced by policies implemented to contain the pandemic and the positive effects of public spending aimed at recovery.

<sup>6</sup>  $R_0$  is the basic reproduction number which is defined as the average number of secondary infections produced when one infected individual is introduced into a host population where everyone is susceptible. In a fully susceptible population, an infection can get started if and only if  $R_0 > 1$ . If  $R_0 < 1$ , a typical infective replaces itself with less than one infective, and the number of infectives tends to zero with the passage of time (e.g. Hethcote 2000).

<sup>7</sup> See, for example, the *World Economic Outlook* (IMF, 2020) in which the projection for the percentage change in output in the Euro Area in 2020 is  $-7.5\%$  with a rebound to  $+4.7\%$  in 2021. It should be noted, however, that in the current world of deep uncertainty, these predictions could be inaccurate. Greenstone and Nigam (2020) indicate that moderate distancing policies have substantial economic benefits in terms of mortality benefits and avoided hospital Intensive Care Unit costs.

<sup>8</sup> The valuation is performed in shadow prices, with the shadow price for an asset being the present value of the contribution to well-being from one additional unit of the given asset.

<sup>9</sup> Sustainability can also be defined in a similar way in terms of comprehensive investment.

Thus, the virus does not destroy reproducible capital per se, but it reduces its utilization through containment policies. However, the pandemic could affect capital accumulation if the recession slows down investment in reproducible capital. COVID-19 seems to be beneficial for natural capital, at least in the short run. Coal use fell by 40% at China's six largest power plants between the last quarter of 2019 and March 2020, while in Europe satellite images showed nitrogen dioxide (NO<sub>2</sub>) emissions fading away over northern Italy, with a similar picture in Spain and the UK (Henriques 2020). According to a recent International Energy Agency (2020) report, global CO<sub>2</sub> emissions are expected to decline during 2020 to 30.6 GtCO<sub>2</sub>, which is 8.3% lower than in 2019 (36.8 GtCO<sub>2</sub>) (Global Carbon Project 2019). This would be the lowest level since 2010, and six times larger than the previous record reduction of 0.4 Gt in 2009 due to the financial crisis.

However, the International Energy Agency (2020) report also indicates that if efforts to contain the virus and restart economies are more successful, the decrease in energy demand could be limited to less than 4%. Since the International Energy Agency's (2020) April report, data show signs of a recovery in carbon emissions. A very recent report—in June 2020—states that new data show a V-shaped recovery in carbon emissions, with carbon emissions declining from February 2020, reaching a minimum in April and then recovering slowly towards the February levels (Domjan 2020).

Regarding human capital, defined in terms of changes in the work force and education level, the pandemic is having a short-term negative effect on work force, but in the long term it might change educational patterns and the geographical structure of the supply of education if extensive on-line teaching is established. Health capital is, of course, negatively affected through the value of statistical life.

The above discussion suggests that the pandemic has a profound impact on the factors characterizing sustainability. Thus, policies to start up the economy after appropriate containment of the pandemic and return to long-term desired growth paths will be beneficial for productive-based sustainability components such as health, human and social capital and reproducible capital through the increase in its utilization.

The issue of primary interest is the impact of recovery-related policies on natural capital and climate change. This issue relates to the way in which the EGD might be adjusted during the start-up period and whether the current beneficial impact of the virus-induced recession on emissions signals a long-term impact.

Recent results in climate science have established an approximately proportional relationship between the change in the global average surface temperature relative to the pre-industrial period (the temperature anomaly) and cumulative CO<sub>2</sub> emissions relative to the same base period (e.g. Matthews et al. 2009). With cumulative emissions since 1850 being approximately  $2400 \pm 240$  GtCO<sub>2</sub> (Friedlingstein et al. 2019), the expected reduction of approximately 6.2 GtCO<sub>2</sub> relative to 2019 due to the COVID-related recession<sup>10</sup> will have negligible effects on the temperature anomaly. Furthermore, if the recovery projections in 2021 are realized, then it is reasonable to expect that the pre-pandemic situation will re-emerge with regard to greenhouse gas emissions, unless the pandemic continues in strong recurring waves which make extended and persistent lockdowns necessary. This situation, however, cannot be regarded as the most likely scenario. If emissions recover in the short or even medium term, the projected time period for crossing the 1.5 °C threshold—according

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<sup>10</sup> For more detailed projections, see Le Quere et al. (2020).

to the business-as-usual or alternative emissions paths—will not be affected in a significant way (IPCC 2018).

In this context, the COVID-19 event is expected to have a negative impact on the global productive base (health, human, social and reproducible capital) and therefore on the global sustainability conditions, while the seemingly beneficial impact on natural capital, and especially climate, will be temporary and a return to pre-pandemic paths is most likely. This means that in the post-pandemic world, risks related to climate change damages, including risks from tipping elements and crossing of climate thresholds, are not expected to change.

How does this picture fit with the European response to COVID-19 in the context of the EGD? The EU is currently developing and implementing a number of policies and stimulus packages to address the recession. The purpose of this note is not to analyse these measures, but rather to explore induced adjustments to the EGD.

It has been reported that there will be some reprioritization of EDG initiatives as a result of the EU response to the pandemic (Involved in Europe 2020). Some of the initiatives such as the renewed sustainable financial strategy, which aims to increase private investment in sustainable projects, or the “renovation wave”, will remain since they are expected to stimulate economic activity; others such as “offshore renewable energy” or “the biodiversity strategy for 2030” might be delayed, but initiatives such as the new EU Strategy on Adaptation to Climate Change and the new EU Forest Strategy will be delayed to 2021.

It is clear that the COVID-19 shock and the need to start up the economy will make substantial policy changes necessary. Looking at sustainability in terms of natural capital and the environment, it should be clear that any short-run improvement is transient, while looking at sustainability in terms of climate change, it is most likely that there will be no change in the long-term trends. What is important is that, after the shock, the start-up will be based on environmentally friendly policies.

Thus, maintaining initiatives such as the renovation wave, or promoting the pillar of cleaner transport, is important. On the other hand, delaying initiatives like the strategy on adaptation to climate change may need to be reconsidered. This is because the rationale behind delaying such strategies seems to be that recovery from the recession is expected to be rapid and therefore the delays will be of short duration and no significant time will be lost.

However, recovery might be impeded or delayed by issues such as new, possibly weaker waves of the pandemic or more technical issues such as fiscal multipliers. Fiscal multipliers during a recession when shocks are concentrated in certain sectors are not expected to be operational, with the multiplier for government spending being around one and the multiplier for transfers likely less than one. These factors might result in the delays—initially projected to be of short duration—extending for a much longer period.

The important point here is that the COVID-19 shock will have a negligible effect on the evolution of the temperature anomaly. Thus, if adaptation activities and decarbonization do not proceed rapidly, the risks of a climate shock will not be sufficiently mitigated. The need for strong action now is exemplified by the fact that the emissions gap in 2030 between current policies and the emissions necessary to keep the temperature anomaly below 1.5 °C in 2100 is approximately 34–39 GtCO<sub>2</sub> (UNEP 2019).<sup>11</sup> The COVID impact

<sup>11</sup> An alternate calculation of the 2030 emission gap, relative to unconditional and conditional nationally determined contributions (NDCs), is still above 30 GtCO<sub>2</sub> (UNEP 2019).

on emissions in 2020 is expected to reduce the gap by approximately 6 GtCO<sub>2</sub>, which falls very far short of the gap that needs to be closed.

The important aspect of a climate shock is that in addition to the negative impacts on the productive base of the economy—human, health and social capital—it will have a much more serious negative impact on the reproducible capital relative to the pandemic. This is because the climate shock will not just reduce the utilization of this type of capital, it will destroy part of the capital stock, since it will affect infrastructure, equipment, buildings and so on. Recovery in such a case will clearly be slower and more difficult.

This creates a serious argument against delaying adaptation programmes which could provide substantial benefits in the presence of climate shocks. Typical adaptation projects (e.g. early warning systems, water resource and flood-risk management, sustainable agriculture, strengthening the resilience of existing infrastructure making new infrastructure resilient) are characterized by high benefit–cost ratios (Fankhauser 2017; GCA 2019).<sup>12</sup> Under the resource constraints imposed by pandemic containment policies and the deep structural uncertainty characterizing the situation, the prioritization of these adaptation policies could necessitate the use of max–min expected utility criteria in decision making. As second-round benefits, adaptation programmes which involve investment could stimulate the economy and provide new jobs.

To summarize, three important points should be taken into account: (i) that the indications thus far suggest that the benefits associated with the reduction of greenhouse gas emissions because of the COVID-19 are transient, which means that the long-term trends associated with climate change are not expected to change, and therefore, mitigation and adaptation strategies should be strongly pursued in the post-COVID-19 era<sup>13</sup>; (ii) that there is a need for an ambitious and comprehensive European economic recovery plan from the COVID-19 crisis (European Economic and Social Committee 2020b); (iii) that climate-change-related investments, in particular in adaptation, are expected to deliver significant economic benefits. Based on these points, it becomes clear that a green recovery plan with resources directed towards achieving the combined objective of both providing the necessary economic stimuli for recovery and also promoting the transition to a low-carbon economy and adaptation to climate change along with investment in natural capital and increase in comprehensive savings could be a feasible and efficient plan.

The EGD is an important strategy for securing the sustained development of the EU and protecting climate as a global public good. At the same time, it is clear that addressing the pandemic requires action now in the form of new policies and changes in priorities. However, although COVID-19 is of necessity in the spotlight at present as a major global threat, it should not displace action aimed at an equal or greater global threat—that of climate change—under the misconception that the temporary drop in emissions during the pandemic allows us to delay climate change action now. A green recovery plan could realistically provide the double dividend of helping the EU economies to recover from the COVID-19 crisis and, at the same time, promote the attainment of a climate-neutral EU.

<sup>12</sup> According to the GCA (2019) study, adaptation investment of \$1.8 trillion in the areas mentioned will provide total net benefits of \$7.1 trillion by 2030, with benefit–cost ratios ranging between 5 and 10.

<sup>13</sup> See, for example, the recent EU European Economic and Social Committee (2020a) opinion about the transition to a low-carbon EU and the financing of adaptation to climate change.

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## 4 Pandemics and the Environmental Rebound Effect: Reflections from COVID-19

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### Introduction

Rebound effect studies have been generally focused on energy use (Sorrell 2007), although some studies for other natural resources have recently emerged (Freire-González and Font Vivanco 2017). Rebound effect occurs when the use of resources is not reduced as expected after a resource efficiency policy or a specific behaviour. Empirical rebound studies aim at capturing the secondary effects of policies and behaviours in order to obtain more adjusted assessments of policies and actions. It is well known in the rebound literature that, counterintuitively, resource efficiency may not reduce the use of these resources, but the contrary. This extreme case is known as backfire, Khazzoom-Brookes postulate, or Jevons' Paradox. Rebound effects are not usually observed by policy-makers, as it requires different perspectives and approaches coming from social, behavioural and environmental sciences. Environmental and social sciences show us that human–environment systems are deeply interconnected. This way of thinking has, however, still not fully permeated in mainstream policy decision circles, which are largely rooted in old intellectual paradigms and other short-term interests.

### Potential Environmental Rebound Effects Post-COVID-19

The pandemic has caused many abrupt changes in production and consumption, transport patterns, working conditions, social interaction and many other aspects. Most of these changes have been triggered by the policies implemented to contain the pandemic. Overall,



they have translated into improvements in most environmental indicators, such as carbon emissions, air quality and biodiversity loss (Saadat et al. 2020). While some authors claim that such changes will not have a lasting impact when the epidemic subsides (McCloskey and Heymann 2020), others argue that aspects related to urban planning, micro-mobility, sharing economy, public transportation, teleworking, tourism, etc., may change for good (Honey-Rosés et al. 2020). An important question is, thus, whether COVID-19 will reduce environmental impacts in the future, when economic activity returns to “normality” (in terms of pre-COVID conditions).<sup>14</sup> Rebound literature shows the importance of considering behavioural and systemic responses to answer this question.

Beyond other considerations, the pandemic has accelerated some already observed trends, like the pace of implementation and use of digital technologies. One of the most remarkable changes are those related to the impulse of information and communications technologies (ICT), due to imposed social distancing rules. There already was a tendency towards an increased use of ICT, but its use has been dramatically accelerated due to the pandemic.<sup>15</sup> This acceleration can be observed in many areas, such as teleworking, e-commerce, remote social relationships, virtual sightseeing, surveillance technologies, and other online areas and events (cultural, academic, leisure, educational, etc.). For instance, in many countries, non-essential workers have been legally obliged to be confined during the pandemic to stop the contagion of the virus, thus promoting telework. Despite the potential advantages of teleworking in increasing labour productivity in many industries (Harker Martin and McDonnell 2012), rigidities in corporate culture and other legal and cultural restraints were hindering and adjourning its consolidation. The use of ICT is thought to be environmentally beneficial, largely due to decreased transport, but this premise has been challenged by rebound effect studies. Gossart (2015) shows that existing evidence suggests that ICT are subject to important rebound effects, mainly because it is a general-purpose technology, and so prone to backfire (Sorrell 2007). Takahashi et al. (2004) calculated the rebound effect of ICT services in a case study on videoconferences and found that rebound can reduce up to 20% of carbon savings. Joyce et al. (2019) recently found for Sweden strong environmental rebound effects associated with ICT use, in most cases far above 100% (more resources use than before). This backfire effect is strongest for energy use and total material footprint, both close to 200%.

Another change may take place in land use and the housing sector, as initial evidence suggests that attributes such as floor space and outdoor space will have elevated importance (Mikolai et al. 2020). The potential re-distribution of time and expenditures towards resource-intensive sectors, such as construction, water and energy services, will likely cause material, water and energy rebounds. However, the expansion of teleworking can, at the same time, reallocate space and incomes in office rental market. City centres will not need to concentrate workspaces, changing mobility patterns and urban structures in the long term (Elldér 2017). Public transport may also be negatively impacted in the short and mid-term, leading to increased private transport (Honey-Rosés et al. 2020), another resource-intensive activity.

Other structural changes may also take place, such as changes in sufficiency measures and broader productivity, leading to macro-economic rebound effects (Lemoine 2017). The pandemic may increase the social acceptance of sufficiency measures such as working less time, spending more time with family and friends, or connecting with nature. These

<sup>14</sup> During the COVID-19 crisis, most environmental indicators have been improved due to confinements and contraction of economic activity.

<sup>15</sup> <https://www.nytimes.com/interactive/2020/04/07/technology/coronavirus-internet-use.html>.

measures have long been proposed to reduce consumption and associated environmental impacts (Hayden and Shandra 2009). These measures have, however, been associated with macro-economic price rebound effects as the decreased demand for some products can lower their price and induce additional demand (Sorrell et al. 2020). Moreover, the post-pandemic society may likely be a more productive one in labour and capital terms. For example, teleworking (Harker Martin and MacDonnell 2012) and increased spending in research and development have been associated with productivity growth, which boosts economic growth and resource use.

### Final Remarks

The COVID-19 pandemic will likely cause a range of changes in society, but their permanence and effect on the environment are unclear, especially if we contemplate the secondary effects of behaviour, measures and policies. A key question is whether they will acquire a certain level of permanence, even modifying the mindsets of agents. Given the high uncertainty around this aspect, its real dimension could only be assessed ex-post. However, due to confinements, the pandemic has greatly accelerated the expansion and use of general-purpose technologies, like ICT. As this has been a long-observed trend, before the irruption of the virus, they have probably come to stay to a large degree.

The pandemic offers a great potential to improving (and consolidating) environmental conditions. But beyond what conventional environmental indicators show, additional measures would be needed to counteract hidden rebound effects and, therefore, take full advantage of potential improvements. Recent literature shows that different economic instruments like environmental taxation, resource pricing or setting limits to resource use, can be effective for this purpose. This is particularly necessary in this case, given the high risk of backfire due to the high expansion of general-purpose technologies observed.

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## 5 Oil Consumption, Air Quality and Health Risks During the COVID-19 Pandemic

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### 1. Motivation

The global financial and commodity markets are facing economic distortions caused by the coronavirus (COVID-19) pandemic (Fernandes 2020; Irwin 2020). COVID-19 acts as a negative shock to overall demand of goods and services, resulting in aggravated short-run volatility in prices (Albulescu 2020). Among these products, oil has been dramatically affected due to community lockdown regulations, shutdown of car factories, decline in energy use and increase in unemployment (Reed 2020a; The Associated Press 2020). However, a decrease in oil consumption may lead to reductions in carbon dioxide emissions (Peña-Lévano et al. 2019). Data recorded by EPA (2020) during March–April 2020 show an improvement in overall air quality, especially in high-density populated cities (Regan 2020).

Air pollution is considered by many scientists as a negative contributor in the coronavirus situation by worsening the susceptibility of infection. A decline in emissions somehow may help prevent mortality temporarily, especially among more vulnerable individuals with underlying health conditions, such as heart and respiratory diseases (Conticini et al. 2020; Dutheil et al. 2020; Mooney 2020; Ogen 2020). Thus, in this short article, we discuss the interaction between fossil fuels, air pollution and health risk under the coronavirus pandemic and the lockdown regulations during the period of March–May 2020.

## 2. Oil Production, Consumption and Resulting Air Quality During the Pandemic

The oil market has been dramatically affected by several exogenous factors during the pandemic period:

- (1) “Shelter in place” mandates aimed at curbing the spread of the coronavirus have decreased people’s social mobility and transportation activities. Households leave their houses just for short travels for some essential errands, such as shopping groceries and/or medicine. Only essential personnel are required to be physically present at their jobs, whereas the majority are working from home (Reed 2020a);
- (2) Commercial flight demand plummeted globally (Reuters 2020). In the USA, the passenger volume dropped 95% from a year ago (compared to April 2019) as estimated by Airlines for America, with an overall reduced accommodation of 12 passengers per carrier (Rappeport and Chokshi 2020);
- (3) Tourism activity slumped as many governments banned international travel, heightened border and immigration controls and barred the entrance of foreign visitors to decrease risk of infection. These policies further decreased the demand for taxis and cruise services. For regions such as the Caribbean Islands (where tourism is a primary economic staple good), this also represents a significant decline in their gross domestic products (Semple 2020);
- (4) Unemployment has pervaded among the national economies (Mazzei and Tavernise 2020). More than 44 million people have filed for unemployment in the USA in a 12-week period (U.S. Department of Labor 2020). This condition is mirrored in other countries. Worsening unemployment conditions have substantially reduced consumers’ purchasing power. Among its consequences is an overall decline in car sales (Reuters 2020; The Associated Press 2020);
- (5) Many industries, restaurants and buildings have been shut down during the lockdown. These closures reduced energy consumption, especially petroleum use, which is a large energy input in the USA and other countries (EIA 2019).

Meanwhile, global oil supply responded slowly to the decline in demand as refineries cannot abruptly halt production (Caldara et al. 2019; Peña-Lévano 2018). The Russia–Saudi Arabia oil price war in March 2020 worsened the situation by oversupplying the market and consequently dropping oil prices (Irwin 2020; Reed 2020a). In April, the major petroleum exporting countries agreed to decrease the world oil output by 10% during May–July, which is equivalent to 9.7 million barrels a day (Krauss 2020; Reed 2020b).

Two recent studies published in *Geophysical Research Letters* validate the realized reduction in nitrogen dioxide (NO<sub>2</sub>) pollution in several regions. Bauwens et al. (2020) compared NO<sub>2</sub> levels in the atmosphere recorded in January to April 2020 and for the same period in 2019. Notably, NO<sub>2</sub>, which is produced by emissions from vehicles and industrial operations, can cause serious lung ailments. Their estimates indicate a significant reduction of 40% in China and 20–38% drop in the USA and western Europe. Shi and Bras-seur (2020) estimate a 60% reduction in NO<sub>2</sub> pollution in Northern China in January and February 2020. In the same period, they also found a 35% reduction in particulate matter pollution (particles smaller than 2.5 μm). While such cleaner air conditions may persist only temporarily, these trends indicate that the desired environmental gains are feasible and realizable if stringent emission regulations, perhaps mirroring to some extent the pandemic’s enforced limits on social mobility and industrial activities, are enforced in the future.

### 3. Air Quality and Health Risk

Several studies relate ambient air quality to mortality and morbidity conditions caused by COVID-19. This contention echoes an earlier correlation applied to the SARS virus outbreak in China in the early 2000s. Researchers from UCLA's School of Public Health analysed air pollution levels and SARS fatality rates among Chinese residents. Their results indicate that SARS patients' probability of dying would be doubled among residents in areas with high air pollution indexes (Cui et al. 2003). As applied to the current pandemic, the Center for Disease Control and Prevention (CDC) explains that COVID-19 causes a respiratory illness with a heightened risk among people who are 65 years and older as well as those with certain underlying health conditions. Latest CDC statistics on the pandemic's severity and fatality indicate that persons with heart ailment, diabetes and chronic respiratory diseases could be at a higher risk of being severely infected by the virus (Vogel 2020). Wu et al. (2020) further clarify that pre-existing health conditions identified as relatively more susceptible to contracting COVID-19 are similar to those normally affected by air pollution in the USA. Their study estimates that an increase of  $1 \text{ g m}^{-3}$  in long-term exposure to particular matter ( $\text{PM}_{2.5}$ ) increases the coronavirus mortality rate by 8%. Isaifan (2020) presents corroborating evidence indicating that 75% of COVID-19-related deaths were cases with pre-existing illnesses, with majority of the victims over 80 years of age. Conticini et al. (2020), however, warn that even young and healthy individuals could also be at risk as prolonged exposure to dangerous air pollutants causing chronic respiratory issues could be an additional co-factor that helps increase their vulnerability to being infected by the virus.

Ogen (2020) establishes that exposure to  $\text{NO}_2$  may be an important instigator of COVID-19 fatalities according to his research involving four European Union countries. These findings are supported by the findings of a study published by the Italian Society of Environmental Medicine (Setti et al. 2020) on virus infections in Northern Italy associated with air pollutants tagged as carriers and boosters.

Poor air quality has been cited as an aggravating factor in virus transmission. Using data from 55 Italian province capitals, Coccia (2020) notes an accelerated transmission dynamics of COVID-19 leading to his conclusion that the spread of this virus can be considered more as following an "air pollution-to-human transmission" mechanism instead of an inter-personal transmission mode. Moreover, Fattorini and Regoli (2020) analyse long-term air quality data in Northern Italy and suggest that chronic exposure to a contaminated atmosphere may have created conducive conditions for the spread of the virus.

Several studies relate the time frame of exposure to toxic air pollutants to mortality and morbidity conditions. Lim et al. (2019) establish a significant association between long-term ozone ( $\text{O}_3$ ) exposure and elevated mortality risk of certain respiratory diseases. Given limited data on the current pandemic, Hoang and Jones (2020) present emerging evidence on the severity of COVID-19 infection attributed to persistent air pollution conditions, thus suggesting that longer exposure to a polluted atmosphere could aggravate virus infection. Zhu et al. (2020), however, provide concrete evidence suggesting that even short-term exposure to air pollution could increase probability of virus infection. Their study analysed daily confirmed cases in 120 cities in China recorded from 23 January 2020 to 29 February 2020 and found significant relationships between the levels of certain air pollutants and the number of newly identified COVID-19-infected cases. Specifically, their results indicate that a  $10\text{-}\mu\text{g}/\text{m}^3$  increase in the air pollutants' levels was associated with about 1.76% to 6.94% increases in daily new COVID-19 cases.

Conversely, the health benefits of cleaner air resulting from reduced emissions from fossil fuel during the pandemic's lockdown period deserve attention. Several studies recognize that improved air quality during the pandemic temporarily mitigated health risks associated with respiratory illnesses. Cole et al. (2020) employed a two-step analytical approach using machine learning techniques and the Augmented Synthetic Control Method to estimate possible reductions in death rates in certain regions in China and for the whole country that may be attributed to actual reductions in NO<sub>2</sub> concentrations during the lockdown period. Isaifan (2020) analyse air quality conditions prior to and during the lockdown period. His results indicate that lives may have been saved due to diminished ambient pollution levels, although eluding possible virus infection still is not necessarily guaranteed. This contention is corroborated by another China-based study conducted by Dutheil et al. (2020). These studies' assertions imply that air quality improvements realized even in such a shorter period of time (spanning less than half of a year) already could have some health benefit potentials, especially in relation to respiratory ailments.

The health benefits of the current pandemic's notable environmental gain in air quality, however, will be optimized only if such favourable conditions are sustained over the longer term. The recent lockdown has been short-lived as some communities nowadays have started to revert to normal social routines and regular users of fossil fuels among industries have resumed operations. A brief respite from a usual contaminated atmosphere does not ensure an effective permanent eradication of chronic health conditions. The pandemic experience, however, demonstrates that better health is maintained and ensured not only through medical remedies and but also through more favourable environmental conditions, if sustained over a much longer period.

#### 4. Final Remarks

Current restrictions on social mobility and economic flexibility under COVID-19 pandemic conditions have actually produced important economic and environmental repercussions that are interestingly contrasting. A general economic slowdown overtly reflected in, among others, reduced consumer demand, spiralling unemployment figures and significant drop in oil consumption causes heightened fears of an imminent economic recession. However, in spite of all the negativity surrounding the pandemic, its environmental consequence of improved air quality is a highly positive note. Interestingly, the global community has been trying to accomplish such feat of attaining better air quality over many years of discussions, policy making and policing each other. Unexpectedly, it took a serious pandemic to realize such feat.

This article traces the interplay of reduced oil consumption with economic issues as well as environmental consequences under pandemic conditions. The more imperative issues now lie on the severity of a looming recession and the global economy's resiliency in transcending the difficult challenges it may bring. Should that happen, will the economic cost burdens be outweighed by the realized environmental gains? Experts may be quick to assert that improved environmental conditions actually may be short-lived as expected resurgence of resumed economic activities may only quickly bring back pre-COVID air conditions. However, proponents of a cleaner world can always draw some inspiration from recent successes in air quality control, especially with the assurance that cleaner air is not necessarily a lofty goal. The challenge in the future lies in achieving such environmental benefit without the need to sacrifice the economic health of the global community.

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## 6 Environmental Impacts and Policy Responses to COVID-19: A View from Latin America

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### 1 Introduction

On February 25, 2020, the Brazilian Ministry of Health confirmed that a 61-year-old man was positive for SARS-CoV-2: COVID-19 had arrived to Latin America. As of 3 July 2020, there have been 2.7 million confirmed cases in Latin America, compared to 1.3 million in the European Union and 2.8 million in the USA (JH-CSSE 2020). Furthermore, so far there have been more than 120,000 deaths in the region and the trends show that the first wave of the pandemic is far from over (*ibid.*).

There is of course no suitable time for a pandemic to arrive, but these are especially complicated times for Latin America. The region is in the midst of a difficult economic situation accompanied by rising social discontent (ECLAC 2020; OECD 2020). Moreover, it is characterized by high rates of informality, health systems with limited and unequal capacity, and most of the countries have high levels of debt (OECD 2020). Under these circumstances, COVID-19 is having major short-run socio-economic effects with possible serious long-run consequences, including several potential implications for the environment and the management of natural resources.

### 2 Short-Run Impacts on the Environment and Natural Resources

#### 2.1 Air Pollution

Restrictions of free movement and circulation within and across urban areas of Latin America have reduced economic activity as well as the use of motorized vehicles. As a result, many Latin American megacities have experienced a short-run decrease in air pollution. Concentrations of NO<sub>2</sub> have decreased considerably in cities all over the region compared to the levels observed prior to the lockdown measures (IADB 2020). Levels of PM<sub>10</sub>, PM<sub>2.5</sub> and CO have decreased in Bogota, Buenos Aires and Quito (Bogota's District Secretary of Environment, personal communication, 3 June 2020; Roa 2020; Rocha 2020).

Nevertheless, the pandemia has not had the same effect on air quality in all the major cities in the region. In Mexico City, the reductions in SO<sub>2</sub>, PM<sub>2.5</sub> and PM<sub>10</sub> concentrations

have been modest, and there has been no reduction in ozone.<sup>16</sup> In Rio de Janeiro, ozone concentrations have increased (Dantas et al. 2020). Furthermore, as the virus and its negative consequences spread across rural areas and make its way through the southernmost part of the region, outdoor and indoor pollution might actually increase. In Mexico, as well as in other countries in the region, the use of firewood is likely to rise as rural households try to deal with income reductions (Maserà et al. 2020). Meanwhile, as winter hits central and southern Chile, urban households might increase their use of firewood for heating given that, due to the lockdowns, they have to spend more time inside dwellings (Encinas et al. 2020). This rise in air pollution could arguably increase the risks associated with COVID-19.

## 2.2 Deforestation

It is too soon to do a formal evaluation of the effects of the pandemic on deforestation and land use change in the region. Nevertheless, the available information suggests that COVID-19 is likely to have negative effects on forest cover across the region. Early deforestation warnings from Peru show that, although deforestation decreased between March 15 and April 15, since then it has increased surpassing the levels observed during the same period in 2018.<sup>17</sup> According to data from the Brazilian National Institute for Space Research (INPE), the first quarter of 2020 already evidenced a rise of 50% in deforested hectares compared to last year's figures. The figures for April 2020 reinforce this pattern, with a 64% increase with respect to April 2019 (Manzano 2020). From January to April 2020, deforestation alerts in indigenous territory increased 59% when compared to the same period of the previous year (Greenpeace Brasil 2020). Although at this point it cannot be claimed that the pandemic caused the observed increase in deforestation, it certainly does not seem to have provided incentives to halt it.

In Colombia, contrary to other countries in the Amazon region, the trend in 2019 showed a reduction in deforestation compared to 2018. However, 2020 started with an increasing tendency and the quarantine seems to have worsened the situation (FCDS 2020). The absence of environmental monitoring during the pandemic seems to have encouraged illegal armed groups and regional mafias to take advantage of the situation, exacerbating deforestation with the possible intensification of illegal activities from which these actors derive income, such as illegal mining, land grabbing and illicit crops (BBC 2020).

According to the Pan American Health Organization, in 18 May 2020 there were already 20,000 COVID-19-confirmed cases in the Amazon basin (Martín 2020). The impact of the pandemic in forest-based indigenous communities is an important source of concern. The spread of the virus in these communities could imply a tragedy that, in addition to the human losses, could affect the traditional knowledge, having negative impacts on the governance of natural resources in the region. This could lead to even more deforestation processes in the future.

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<sup>16</sup> Own estimations using data from Mexico's City Ministry of the Environment, available at [www.aire.cdmx.gob.mx](http://www.aire.cdmx.gob.mx).

<sup>17</sup> Own estimations using data from geobosques, available at <http://geobosques.minam.gob.pe/>.

## 2.3 Other Impacts on the Environment and Natural Resources

COVID-19 has caused a disruption in the national and international trade of nature-based goods and services. Tourism has come to a halt, affecting the economy of almost all of the countries in the region (Mooney and Zegarra 2020). In countries like Costa Rica, where the touristic industry is intertwined with nature, the shock to the sector could have negative effects for biodiversity and forests. Without income from tourism, and given that as a slow recovery process is anticipated, the incentives to protect forests are expected to decrease in the short and medium run. Fishing and aquaculture are other industries that have been negatively affected. Information for the case of the Chilean salmon aquaculture industry suggests that there has been a reduction in demand from international markets (Chávez et al. 2020). The effect of the shock is being transmitted through the value chain, affecting processing plants and farming facilities.

## 3 Potential Effects on Environmental Policies and Regulations

The economic crisis can end up having long-run negative consequences for the environment if, as a result, regulations and environmental policies are relaxed or if institutions are weakened. Although at this point there is no evidence of any country in the region purposefully relaxing environmental regulations to promote growth, it is certainly a possibility. What has been observed is that, in order to fund measures to reduce the economic and social impacts of the pandemic, some countries have decided to reallocate funds across the public administration. Ecuador, for example, announced cuts affecting the ministry responsible for enforcing environmental regulations (BBC News 2020). Something similar is happening in Mexico, where the plan announced by the President is to reduce the operational budget of almost all government entities by 75% (D.O.F. 2020). Even if countries have a relatively strong environmental legal framework, without a budget to monitor and enforce the regulations, this framework is worthless.

Countries in the region will very likely incur fiscal deficits and increase their debts in order to fight the crisis. It remains to be seen how the service of the increased debt will impact economic growth and the environment. In the meantime, it seems that the short-run legitimate demands to recover employment levels and improve the health systems might very well push aside the necessary investments to successfully tackle climate change and biodiversity loss. If this indeed happens, it could be the most serious effect of the COVID-19 pandemic in both environmental and social terms.

## 4 Discussion and Research Agenda

The economic projections suggest that the region will experience a crisis whose magnitude has no precedent in modern history (ECLAC 2020). In order to overcome this apparently insurmountable challenge, Latin American countries will need well-designed policies that should reconcile economic objectives with social and environmental goals. The social unrest manifested recently in the social mobilizations in the region, should make clear that the apparent trade-off between economic, social and environmental objectives is the result of a false dichotomy between short- and long-run objectives. If environmental objectives are put aside, as has so often happened with social objectives, the economy might recover in the short run but at a very high price.

The lockdown measures seem to be having a temporal positive effect on reducing urban pollution in some Latin American cities. The challenge now is how to intervene to prevent a return to the same or even higher pre-quarantine emission levels. This is an opportunity to rethink the urban environmental policies while trying to recover from an unprecedented social crisis. At the same time, the observed increase in deforestation reopens political and

academic debates about the role of national parks, indigenous reserves and other protection categories in a context of deteriorated livelihoods, illegal economies and a lack of state presence.

Latin American countries could see this moment as an opportunity to improve regional cooperation in order to design and implement coordinated policy responses not only to the economic crisis but also to the challenges of mitigation and adaptation to climate change. Furthermore, countries should coordinate efforts to increase monitoring and presence in the region to effectively reduce deforestation.

We have presented an account of some of the most evident environmental effects that the COVID-19 pandemic is having in Latin America at this point. Considering that we are in the midst of the health crisis and in the beginning of an economic one, it is natural to expect that the trends that we see now will change in the near future and that other environmental impacts will become evident. Research that contributes to a better understanding of the environmental impacts and the effectiveness of different policy responses to the pandemic in Latin America will be invaluable. There are many potential paths for future research; here, we mention just a few.

The consequences of the interactions between poor air quality and COVID-19 on human health are clearly worth studying. This is particularly relevant for the Latin American context, characterized by health systems with very limited capacity and high numbers of population without formal employment. Results from studies in this area could help us provide better guides to set environmental quality goals, as well as to implement policy interventions that can reduce pollution in the region's context of income inequality and spatial segregation.

The short-run environmental effects of COVID-19 show early warnings of an increase in the pressure on forest and other ecosystems across Latin America. Understanding the impacts of the pandemic on terrestrial and marine ecosystems, as well as on livelihood opportunities for local communities, has the potential to contribute to the design of policies which can improve management and conservation.

The pandemic is opening new research questions regarding the impacts of global shocks on natural resource-based industries that participate in international markets. Furthermore, the paths that different countries take to get out of the economic crisis might have profound impacts on international trade. If, for example, the world transitions to more reliance upon local production, or if emissions-related tariffs are imposed, large exporters of commodities in the region will be highly affected. The impacts that these potential trade changes could have on the environment are unknown. Furthermore, if developed countries implement recovery plans that include provisions to reduce emissions in significant ways, as has been discussed in the European Union, will Latin American countries be able to respond in the same way? In any case, Latin American countries are highly vulnerable to the effects of climate change and some of these effects (e.g. migration) could result in future health crises. A better understanding of the ways in which individuals might adapt to a changing climate, as well as of the barriers that they face to adopt adaptation measures, will be a valuable tool for the design of adaptation policies that prevent future health crises in the region and elsewhere.

The distributional and gender-differentiated impacts of the pandemic, and the related environmental policy responses, is another area that deserves attention, especially because early evidence shows that the more vulnerable segments of the population in the region are the ones that are being hit hardest. Finally, as has been recently pointed out by Helm (2020), the experience of the pandemic might lead to changes in behaviour and personal choices. It remains to be seen if this is in fact the case, and if so, how are these changes in behaviour modulated by the local context. An even more important issue to consider

is what would these changes imply for the design of behaviour-based policy instruments aiming to change consumption and production patterns, as well as transport and land use decisions in Latin America.

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## 7 Novel Policy Research on the Resource Exporters-Energy Policy Nexus During the Coronavirus Pandemic

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Resource exporters are now facing new urgent economic policy challenges due to COVID-19. These challenges are aggravated due to their dependence on finite commodities with volatile prices and demand. In response to the pandemic, resource exporters (such as Botswana and Saudi Arabia) announced cuts in expenditures along with large fiscal (tax relief) and consumption-focused macroeconomic stimulus packages. Critically, the novel issues raised by the coronavirus pandemic bring new trade-offs of energy policy between short-term gains and long-term sustainability, creating an urgent need for critical, quantitative, policy-focused research in the resource exporters-energy policy nexus.

A few novel issues emerged in resource exporters during the pandemic that give rise to short-term economic challenges. *First, price shocks of unprecedented magnitude for commodities* (Deutsche Bank 2020; World Bank 2020), from coffee (Hernandez et al. 2020) to hydrocarbons (IEA 2020b), causing a large drop in energy investment (IEA 2020a). For oil, prices dropped initially due to travel bans and economic activities hiatus, and further with oil price wars following the collapse of OPEC<sup>+</sup> agreement. By April 2020, with oversupply, the rise of stockpiles, and the saturation of available oil storage, oil prices reached the lowest level in more than 20 years, and West Texas Intermediate (WTI) reached negative levels for the first time. Prices have subsequently partially recovered but are expected to remain low with continuous fears of new COVID-19 waves and uncertain demand. *Second,*

<sup>18</sup> Thanks are due to two anonymous referees. Funding support is provided by the Kuwait Foundation of the Advancement of Sciences, Kuwait.

*unprecedented economic contraction*, because the pandemic-triggered decline in economic activity was significantly exacerbated by declines in export revenue. *Third, unprecedented fiscal pressure*, resulting from costs of fiscal and economic stimulus packages plus a simultaneous rise in domestic expenses (especially healthcare and unemployment benefits) and sharp declines in resource export revenue. The effects have been so colossal that states like Kuwait are considering halting legally-mandated contributions to the future generations sovereign wealth fund (SWF) to ease fiscal pressures (Al-Zo'bi 2020). *Fourth, record and continuous withdrawals from SWFs* to fund post-pandemic recovery along with reallocation of funds and increased government debt (examples in Arabian Business 2020; Holter and Bloomberg 2020). Even states with the largest SWFs such as Norway and Kuwait have been affected, with the latter expecting depletion of its fiscal stabilization SWF (Al-Zo'bi 2020). *Fifth, in oil-exporting Gulf states, the unusual stay of millions of citizens and guest workers in the upcoming scorching summer* in lieu of usual tourism travel or home-country visits, pressuring existing energy capacity.

Critically, in oil exporters, these novel issues and policy responses to them further expose existing economic fragilities and challenges, threatening long-term economic and environmental sustainability. For distorted oil economies in urgent need for economic diversification, said diversification and reverse Dutch disease are impeded by their existing high distortions in labour, fiscal, industrial and energy markets (Shehabi 2020). Oil exporters suffer from economic inefficiencies resulting from pervasive oligopolies (Shehabi 2017) and market failure in long-run contracts for exploration and development of natural resources (Ruta and Venables 2012). Fossil fuels are the primary source of energy in most oil exporters. In developing oil exporters, the dominant political economy undergirding policy making is a welfare rentier state, in which maintaining a political equilibrium is central. Balancing spending-saving decisions for sustainable resource rents management depends on the sustainability of windfall expectations (Gelb and Grassmann 2010). Reforming energy policy—which drives fiscal, industrial and environmental policies—is critical for these states' long-term development. Yet the novel issues create new trade-offs of post-pandemic energy policy: achieving short-term gains will be at the expense of long-term gains in resource economies. Thus, it is critical for fast policy-focused research to address the resource exporters-energy policy nexus, especially in the following two areas.

**1. Trade-offs between energy transition and economic recovery.** Although investments in renewables have been more resilient than in fossil fuels, and while we have seen an increased share of global energy spending on clean energy technologies in 2020 (IEA 2020a), the reality in hydrocarbon-exporting developing states is different. Global oil market supply and demand dynamics have raised their opportunity cost for transitioning away from fossil fuels and for investing in green technology. Accordingly, post-pandemic economic stimuli might achieve short-term recovery but harm long-term energy transition. First, the rise in opportunity costs of energy transition will facilitate the reallocation of funds away from renewables projects towards post-pandemic economic stimuli (similar to “green tape” cuts in Australia and Canada). Second, recovering lost investments in energy transition projects is unlikely because the resource rents that fund them are likely to continue to be low in the future, given low resource prices and demand pressures of climate change mitigation. Third, continuous withdrawals of diminishing SWFs will entail limited resources for future energy transition projects. This is especially so as recovering SWFs' withdrawals is unlikely in the light of expected low resource export revenue and the collapse in financial and commodity markets accompanying the unprecedented global

recession.<sup>19</sup> Finally, economic stimuli expand consumption and welfare redistributive measures, which increase greenhouse gas (GHG) emissions (Helm 2020) and exacerbate existing distortions that have been shown to prevent economic and energy diversification (Shehabi 2020).

New research should investigate the design and implementation of new economic solutions that have at their forefront long-term energy transition goals along with short-term economic recovery. Three policy solutions are suggested at the consumer, the energy industry and economy-wide levels. A policy solution to target consumers is technological advancements (both private and public funded) in energy efficiency coupled with economic incentives to rationalize energy consumption. This policy combination can achieve energy transition goals despite expected delays in renewables and without requiring large multi-year investments. It is especially important in Gulf oil states where skyrocketing cooling and desalination needs in the summer will be met using fossil fuels (renewables contribute less than 1% of power generation). A policy suggestion at the sectoral level is investing in clean energy technologies to decarbonize the energy sector itself, namely through carbon capture and storage as well as hydrogen. Beyond short-term economic and environmental benefits, these investments can keep oil exporters relevant in a future with a diminishing role of hydrocarbons and collapsing commodity prices. The final policy suggestion is microeconomic and energy policy reform that can moderate effects of export price declines on the economy without the need for additional cuts in renewables investments or further withdrawals from SWFs. Examples include microeconomic reforms of labour and human capital to increase long-term productive capacity and oligopoly regulation in non-tradables and energy sectors which can increase efficiency and welfare gains that translate economy-wide (Shehabi 2020). Consequently, resource rents could be salvaged for SWFs resources or investments necessary for future development.

**2. Negative long-term effects of energy and carbon pricing policy on the environment.** In the light of the aforementioned novel issues in resource exporters, the post-pandemic energy policy and economic stimulus packages are likely to have negative long-term effects on the environment. The reasons are as follows. First, while lockdown measures that minimized transportation and human activity reduced short-term emissions, they also increased power demand which in resource exporters is met mostly through fossil fuels, especially as international demand and prices remain low. Second, short-term improvements will be negated upon the resumption of human activity, absent changes in energy policy regimes. Importantly, as domestic energy prices remain low and highly subsidized in developing resource exporters, the extent to which COVID-19 restrictions would shift energy consumption habits and behaviours of agents (households and institutions) remains very doubtful. Third, there will be limited resources in the future to dedicate towards environmental regulation and GHG emissions reduction. The reason is that funding the post-pandemic recovery will reallocate funds away from environmental projects and savings in SWFs. Fourth, GHG emissions will increase due to consumption-focused economic stimulus packages and expanded use of fossil fuels

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<sup>19</sup> Following from the earlier example, the reported amount of Kuwait's withdrawal from its Future Generations Fund in 4 months to manage the pandemic (KWD 13 million/USD \$42 million) is the equivalent of over 14 years of contributions at the current contribution rate (10% of oil export revenue) if oil prices and demand were as high as those in 2015. Nevertheless, the expected low future oil prices and demand will mean inability to recover said withdrawals from oil rents.



to meet rising energy demand. This is particularly problematic because even prior to the advent of the pandemic, resource exporters were among the highest energy consumers and carbon emitters globally. Indeed, the ten highest per capita carbon emitters are all resource exporters, with emissions ranging from 49 tonnes (t) per capita (Qatar) to 16.7 t per capita (Kazakhstan), more than 3.5 times the global average of 4.8 t per capita (Ritchie and Roser 2017). Finally, and most importantly, the implementation of policy instruments—namely energy subsidy reform and carbon taxes—to achieve resource exporters' Intended Nationally Determined Contributions (INDCs), is rendered significantly more difficult post-pandemic. It is a consequence of the magnitude of novel economic contraction and fiscal pressures in welfare-based states. These additional political constraints exacerbate environmental laws' enforcement, for which there already was a widespread failure in resource exporters (UNEP 2019).

Therefore, new research must quantify effects of proposed economic stimuli and of rising use of fossil fuels on resource exporters' environment and economy and accordingly evaluate and design new alternative policies that can achieve short-term recovery and national climate target goals. To that end, four policy suggestions are offered. First, reducing emissions in ways other than the politically difficult tax instruments, mainly through enhancing energy efficiency that reduces emissions at a given consumption level coupled with economic incentives that reduce energy consumption. Second, implementing carbon tax instruments in ways that do not harm the most vulnerable of populations and reduce resource exporters' fiscal distortions, thus achieving a "double dividend". Third, in the light of the novel issues, a key policy solution is adopting "green welfare expansion": including green options in the typical post-pandemic welfare packages at lower governmental budgetary requirements. Examples include expanding subsidies for green technologies (such as solar panels, public transportation or electric cars), as well as excluding from subsidies non-essential high-carbon-emitting products for households above a certain income level. Fourth, increasing the political viability of green recovery packages (such as clean physical infrastructure and natural capital investments), including engaging the private sector in initiatives that are typically public-led—such as climate finance, renewables expansion and resource mobilization. This policy is critical because, although green recovery packages may boost economic growth while helping climate change (Hepburn et al. 2020), they are politically contentious in resource exporters where they compete with welfare distribution.

Critically, applicable to the aforesaid two research areas, the pandemic offers resource exporters an opportunity to engage in a comprehensive reform agenda that addresses short-term pandemic effects while advancing long-term energy transition, economic and resource sustainability. The challenge for policy makers is to avoid implementing policies in haste. Properly coordinated policy reforms offer an avenue to address inefficiencies and underlying structural distortions in a way to realize mutual gains and multiple policy objectives at the lowest cost.

In designing these reforms and addressing the two areas above, the most suitable research methods are economy-wide general equilibrium models that can quantify effects of shocks and policy solutions in a "second-best" environment. This feature is necessary given the large existing economic distortions in resource economies. These models represent economic linkages and agents and include a wide range of policies (energy, carbon, fiscal, labour or industrial). As such, they can inform evidence-based policy making that accounts for political economic considerations. This research will be critical for filling gaps in the literature on long-term economic and resource sustainability in resource exporters.

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## 8 In the Name of COVID-19: Is the ECB Fuelling the Climate Crisis?

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### Introduction

The current global greenhouse gas (GHG) emissions trajectory indicates that the world is likely to experience catastrophic consequences due to climate change, unless swift action is taken towards funding green solutions and the defunding of fossil fuel activities (IPCC 2018). While there is an extensive academic literature on the links between environmental and fiscal policies and the low-carbon energy transition (Aghion et al. 2016; Ambec et al. 2013; Cojoianu et al. 2020), as well as on optimal environmental policies in times of economic downturns (van den Bijgaart and Smulders 2018), we know less about what the role of central banks is in promoting a green economic recovery and how monetary policy objectives interact with climate change mitigation objectives in the short and long term (Battiston and Monasterolo 2019; Matikainen et al. 2017).

Given the ambition of the European Union to become a net zero-carbon economy by 2050 and the numerous calls to avoid the bailout and stimulus packages towards fossil fuel companies (Hepburn et al. 2020), we examine whether the features of the European Central Bank's (ECB) €1350 billion Pandemic Emergency Purchase Programme (PEPP) encourages the resilience of the incumbent fossil fuel sector, or whether it promotes the growth of the emerging low-carbon energy sector during the COVID-19 pandemic and beyond.

We draw on a novel dataset of corporate bonds issued in the European energy sector between 1 January 2020 and 19 June 2020 in combination with the European Central Bank's (ECB) purchases under the Pandemic Emergency Purchase Programme in response to COVID-19. We show that the likelihood of an energy company bond to be bought as part of the ECB's programme increases with the GHG intensity of the bond issuing firm. We also find weaker evidence that the ECB's PEPP portfolio during the pandemic is likely to become tilted towards companies with anti-climate lobbying activities and companies with less transparent GHG emissions disclosure in the event of increased Euro-denominated bond issuances in the following months, or re-denominations of non-Euro bonds already issued by European energy companies.

**Table 1** Main statistical models

Dependent variable: ECB = 1 (if bond is purchased by ECB) ECB = 0 (otherwise)	Model 1 Bond denomination EUR	Model 2 Bond denomination EUR	Model 3 Bond denomination EUR	Model 4 Bond denomination all currencies	Marginal Effects (at mean) Bond denomination EUR	Shapley pseudo-R-squared decomposition by factor
Pro-climate lobbying activities score			-0.475 (0.388)	-0.935** (0.455)	-0.101 (0.082)	10.92%
GHG disclosure completeness		-0.706 (0.857)	-0.820 (0.919)	-1.616*** (0.601)	-0.175 (0.188)	1.97%
GHG intensity	0.983*** (0.281)	1.067*** (0.311)	0.907*** (0.292)	0.983*** (0.294)	0.193*** (0.067)	51.86%
Revenue	-0.608** (0.244)	-0.606** (0.246)	-0.750*** (0.264)	-0.702*** (0.204)	-0.160*** (0.053)	15.05%
Bond issuance amount	0.428 (0.584)	0.519 (0.647)	0.217 (0.700)	-0.217 (0.413)	0.046 (0.148)	3.21%
Bond issuance coupon rate	-0.578 (0.444)	-0.643 (0.468)	-0.822 (0.514)	-1.523*** (0.444)	-0.175 (0.109)	16.99%
Constant	0.379 (0.321)	0.464 (0.363)	0.511 (0.380)	0.236 (0.362)		
Observations	52	52	49	68	49	49
Pseudo-R-squared	0.163	0.169	0.177	0.348	0.177	0.177 (100%)
Log-likelihood	-28.56	-28.36	-26.04	-30.66	-26.04	-26.04

Likelihood of bond issuance to be bought by ECB. Data from Bloomberg, ECB and InfluenceMap (Logit model)

Significance levels:  $p < 0.01^{***}$ ,  $p < 0.05^{**}$ ,  $p < 0.1^*$ . All variables are standardized (mean = 0 and standard deviation = 1), with the exception of GHG disclosure completeness, which takes the value 1 if Scope 1 GHG emissions reporting is transparently reported and 0 otherwise (based on the ES074 score compiled by Bloomberg). Hence, the coefficients can be interpreted as a one standard deviation change in the independent variable is related to a  $\beta$  change in the log odds ratio (or  $e^\beta$  change in the odds ratio) of the dependent variable. The marginal effects show the coefficient at a one standard deviation increase around the mean of the specific independent variable (as variables are standardised). The Shapley R-squared decomposition shows the relative statistical explanatory power of each independent variable

## Policy Background: Climate Change and the ECB

Many central banks remain of the view that central bank interventions should be market-neutral and not discriminate between sectors in the low-carbon energy transition (Matikainen et al. 2017). That does not mean, however, that the aim of central banks to remain sector neutral is achievable in practice, as the implementation of ECB's post-2008 quantitative easing shows that assets purchased by central banks to stimulate overall economic growth are benefitting more from the policy than assets which are not purchased by the bank (Haldane et al. 2016; Matikainen et al. 2017). This means that the choice of asset class through which asset purchasing programs are implemented matters. This is particularly important in the low-carbon economy context, as the fossil fuel energy sector is largely financed through bonds and syndicated bank loans (Cojoianu et al. 2019), whereas much of the emerging clean technology companies are financed through private equity, equity issuances and asset financing (Cojoianu et al. 2020; Gaddy et al. 2017).

Given that the ECB has chosen to enact its asset purchasing program post-2008 crisis predominantly through bonds, this has been shown to favour the incumbent fossil fuel industry (Battiston and Monasterolo 2019; Matikainen et al. 2017), as 62% of ECB's corporate bond purchases (out of a total of €82 billion) are in GHG intensive sectors—though they make up only 18% of the Eurozone area economy and produce 59% of GHG emissions.

The criteria for the corporate bonds bought under the PEPP are that: (i) the company must be incorporated in the Eurozone and its bond issuance denominated in Euro, (ii) the firm cannot be a financial corporation (or a credit institution supervised by the ECB), (iii) it cannot be a public entity, (iv) the bond issuance has to be endorsed by one positive credit rating by an external credit assessment institution accepted within the Eurosystem credit assessment framework and (v) they have a maximum maturity of up to 31 years and a minimum maturity of 6 months.

## Data and Methodology

In order to understand whether the ECB's bond buying activity during the COVID-19 pandemic has been tilted towards less transparent, more fossil fuel intensive as well as anti-climate lobbying European energy companies, we undertake the following steps. First, we collect all the bonds issued by European energy companies during the period 1 January 2020 to 19 June 2020 from Bloomberg. These span the following energy subsectors as classified by Bloomberg Industry Classification System (BICS): power generation, renewable energy, integrated oil and gas companies, oil and gas exploration and production, oil and gas services and utilities. This results in 159 bonds. We then match each bond with ECB's bondholding portfolio,<sup>20</sup> the borrower's record on pro/anti-climate lobbying from InfluenceMap, the GHG intensity of the borrower (collected from Bloomberg and measured as thousands tCO<sub>2</sub>-e/million EUR revenue) and the GHG reporting completeness of the borrower (which is assessed by Bloomberg and quantified as 1 if the company is transparent about the organisational boundary it chooses to quantify its GHG emissions and 0 otherwise, Bloomberg terminal code ES074). We further collect the borrower's revenue (million EUR), bond amount issued (million EUR) and coupon rate for each bond, also

<sup>20</sup> <https://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html>.

from Bloomberg. Our resulting dataset with complete data across all variables of interest is comprised of a cross-section of 68 bonds issued across several currencies, and 52 Euro-denominated bonds.

Our *dependent variable* quantifies the likelihood that the bond of a European energy company is bought by the ECB during the first 5 months of 2020 and coded as 1 if it has been bought by the ECB, and 0 if it has not. For our model, we employ a binary logistic regression model with robust standard errors. The full model specification is the following, where  $\varepsilon_i$  is the stochastic error:

$$\begin{aligned} \text{ECB Bond}_i = & \beta_0 + \beta_1 * \text{Pro-Climate Lobbying Activities Score}_i + \beta_2 * \text{GHG Emissions Intensity}_i \\ & + \beta_3 * \text{GHG Reporting Completeness}_i + \beta_4 * \text{Borrower Revenue}_i \\ & + \beta_5 * \text{Bond Issuance Amount}_i + \beta_6 * \text{Bond Coupon Rate}_i + \varepsilon_i. \end{aligned}$$

## Results and Discussion

We show that after controlling for the revenue of the issuer, the bond amount raised and the rate of the coupon, the ECB is statistically significantly more likely to buy the bonds of more GHG intensive European energy companies (Models 1–4, Table 1). On average, a one standard deviation increase in the GHG intensity of an energy company results in a 147% increase in the likelihood that its bonds are bought by the ECB ( $\beta=0.907$ ,  $p<0.01$ , odds ratio: 2.47, Model 3).

When we consider only Euro-denominated bonds (Models 2 and 3), which are directly under the remit of the ECB, GHG disclosure completeness and pro-climate lobbying are statistically insignificant, yet negative, which suggests that the ECB may be likely to tilt its portfolio towards companies with poorer GHG emission disclosures and less responsible climate lobbying activities. Subsequently, we include the bonds issued by European energy companies in denominations other than Euro, to account for potential sample selection bias due to the choice of energy companies to abstain from issuing Euro-denominated bonds as they may have received discouraging signals from the ECB. In other words, analysing the bond issuance of European energy companies in all currencies considers signals that the ECB may have given to the energy companies prior to issuance, while analysing only Euro-denominated bonds only considers the observable decision of the ECB to purchase the bonds of specific energy companies post-issuance. When we do so (Model 4), it emerges that considering the entire universe of bonds issued by European energy companies, the ECB's portfolio is tilted not only to those energy companies that are more GHG intensive, but also to companies which are less transparent on their GHG Performance as well as those companies who are more likely to oppose progressive climate action. Having established statistical significance, we investigate the economic and statistical relevance (Brooks et al. 2019). Inspecting the economic relevance of the GHG intensity variable in Model 3, we find GHG intensity to have the largest marginal effects. In terms of statistical relevance, we find GHG intensity to have by far the largest Shapley R-squared value, contributing more than 50% to the overall explanatory power of Model 3. In conclusion, the importance of GHG intensity is underlined by its marginal economic effects and its statistical relevance, as it explains more variation in the dependent variable on its own than all other variables taken together. We also conduct further robustness tests controlling for

bond maturity, bond rating and interactions of key variables and find our results to remain statistically significant.<sup>21</sup>

In conclusion, drawing on a novel dataset of corporate bonds issued in the European energy sector since January 2020 and the database of ECB's purchases under the PEPP in response to COVID-19, we find evidence that the likelihood for a bond to be bought by the ECB increases with the GHG intensity of the bond issuing firm. We also find weaker evidence that the ECB's PEPP portfolio during the pandemic is likely to become tilted towards companies with anti-climate lobbying activities and companies with less transparent GHG emissions disclosure.

Our findings imply that, at later stages of the COVID-19 recovery, an in-depth analysis may be necessary to understand if, and if yes, why the ECB fuelled the climate crisis. Even if one accepts that fossil fuel companies were eligible for PEPP, then our preliminary evidence still raises the significant question, why the ECB was more likely to directly finance those fossil fuel firms that are likely more harmful to the planet (i.e. have a higher GHG intensity)?

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## 9 Never Waste a Good Crisis: COVID-19, Macroeconomic Effects and the Way Forward<sup>22</sup>

### A bird's eye view of COVID-19 Macroeconomic Shock and Response

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The coronavirus COVID-19 pandemic is the defining global health crisis of our time, causing over half a million deaths to date (1 July 2020).<sup>23</sup> But COVID-19 is much more than

<sup>22</sup> This short paper is based on the first author's working paper <https://www.unsdsn.org/never-waste-a-good-crisis-for-a-sustainable-recovery-from-covid-19>, April, 2020.

<sup>23</sup> <https://ourworldindata.org/grapher/total-deaths-covid-19>.



a health crisis, it has tremendous socioeconomic impact, the scale of which is still hard to assess. Measures to address the health crisis generate economic impacts (and vice versa). Social isolation measures to “flatten the curve of the pandemic” buy time to increase capacity in the healthcare sector but inevitably deepen the macroeconomic recession.

The World Bank<sup>24</sup> expect the global economy contract by 5.2% in 2020, approximately three times the size of the 2008–2009 Great Financial Crisis (GFC) and far more widespread. Emerging Markets and Developing Economies (EMDEs) have been severely hit by massive capital outflows, reducing debt servicing abilities (especially for dollar-denominated debt) and generating long-term challenges; “With more than 90% of EMDEs expected to experience contractions in per capita incomes this year, many millions are likely to fall back into poverty” (World Bank 2020).

The economic consequences of the adverse coronavirus shock are: (i) an elevation of uncertainty, which increases precautionary savings, thus reducing consumption and also curtails the appetite for productive investments; (ii) a rise in unemployment, part of which is likely to be permanent; (iii) a decline in the volume of international trade and disruptions in global supply chains; (iv) falls in commodity prices (especially the price of oil), making current account financing of traditional commodity exports challenging; (v) a sharp increase in the required risk premia for holding risky assets. This initially resulted in a plunge in prices of risky assets (e.g. stocks or high-yield bonds) and a sharp increase in financial volatility. However, Central Bank interventions (especially by the Federal Reserve of the United States of America—US FED) have seen recoveries from March 2020.

Extraordinary macroeconomic policy response, on both the fiscal and monetary fronts, has slowed the rates of economic decline. In many countries, fiscal measures have replaced a proportion of lost incomes and mitigated default risk, loan guarantees have helped keep businesses afloat, and liquidity provision by central banks have kept the financial system functional. Fiscal authorities in European and the USA took measures that can be classified within three broad categories: immediate fiscal measures and direct transfers to households; tax deferrals and liquidity measures; and loan guarantees. The scale of intervention is truly unprecedented reaching almost 50% of 2019 GDP in Germany and 15% of GDP in the USA.

On the monetary front, the FED cut interest rates to zero, announced unlimited purchases of treasuries and mortgage backed securities and started buying corporate debt. Moreover, the FED opened debt swap lines with 14 foreign central banks to provide dollar liquidity to the international financial system. The value of FED measures to date exceeds 2.3 trillion dollars.<sup>25</sup> The European Central Bank ECB “has offered low-interest loans to banks, significantly boosted asset purchases, and allayed fears of member-country defaults by lifting distributional restrictions on its bond-buying program” (World Bank 2020). Moreover, the EU’s Recovery Plan<sup>26</sup> (proposed 27 May 2020) mobilizes investments through a recovery instrument of €750bn for the period 2021–2024 and a reinforced a long-term budget of €1.1 trillion for the period 2021–2027.

Despite these unprecedented measures, the course of the pandemic and its developing economic impact remains uncertain. How can long-term economic dislocation be avoided?

<sup>24</sup> World Bank. 2020. Global Economic Prospects, June 2020. Washington, DC: World Bank. <https://doi.org/10.1596/978-1-4648-1553-9>.

<sup>25</sup> World Bank. 2020. Global Economic Prospects, June 2020. Washington, DC: World Bank. <https://doi.org/10.1596/978-1-4648-1553-9>.

<sup>26</sup> [https://ec.europa.eu/info/live-work-travel-eu/health/coronavirus-response/recovery-plan-europe\\_en](https://ec.europa.eu/info/live-work-travel-eu/health/coronavirus-response/recovery-plan-europe_en).

A first priority should be to ensure that the work force remains employed. Second, governments should channel financial support to public and private institutions that support vulnerable citizen groups. Third, Small Medium Enterprises (SMEs) should be safeguarded against bankruptcy. (The need for taxpayer money to support large nonfinancial corporations is much less obvious.) Fourth, policies will be needed to support the financial system as nonperforming loans mount. Fifth, fiscal packages, comparable to the loss of GDP, will have to be financed by national debt. While this should be structured to avoid another debt crisis, finance should be directed to investments with positive social, economic and environmentally sustainable profiles, as discussed in the following.

### **The Way Forward to a Climate-Neutral, Resilient and Sustainable Future**

There is widespread scientific speculation that economic growth has pushed humanity into new ecological niches wherein humans and animals exchange novel, infectious viruses of which COVID-19 is just the latest in a considerable list of examples. Furthermore, the Intergovernmental Panel on Climate Change

(IPCC) has warned that global warming will likely accelerate the emergence of new viruses.<sup>27</sup> Overall, climate change has the potential to end up killing more people than COVID-19, although this is obtusely referred to as an “increased frequency and severity of natural disasters”. Such language, the delayed, cumulative nature of the threat and the necessity of coordinated international response, all mitigate against the urgent action that is required. Timing is also important. As IPCC (2018) reports, the level and speed of change needed to successfully tackle the climate crisis, is unprecedented; incremental changes will not be enough. That said, there are aspects of the climate change crisis which are less challenging than the COVID-19 pandemic. As Sterner (2020) notes, the climate crisis requires policy changes that are less disruptive, economically, socially and culturally, than the measures being taken right now to tackle COVID-19. For the climate, we do not need to close down the economy. On the contrary, we need a transition to a low-carbon economy that supports public and private investments in renewables, energy efficient and circular, technologies and infrastructure. These technologies exist (wind, solar, etc.) and are becoming consistently cheaper than fossil fuels, while energy storage installations are increasing exponentially.

There is growing evidence that green stimulus policies have advantages over traditional fiscal stimulus and that climate-positive policies also offer superior economic characteristics. For example, Hepburn et al. 2020 run a global survey to assess stimulatory fiscal recovery policies implemented in response to GFC. The economists from 53 countries were asked to ascertain their perspectives on COVID-19 fiscal recovery packages according to: “speed of implementation”, “long-run economic multiplier”, “climate impact potential” and “overall desirability” according to social, political and personal factors. The responses indicate that green stimulus policies deliver higher multiples due to reduced long-term energy costs and flow-on effects to the wider economy.

### **Seizing the Day: A Green Recovery from the COVID-19 Pandemic**

“Relaunching the economy does not mean going back to the status quo before the crisis but bouncing forward. We must repair the short-term damage from the COVID-19 crisis in a

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<sup>27</sup> Intergovernmental Panel on Climate Change, 2018.

way that also invests in our long-term future”.<sup>28</sup> This code explains the strategy of the EU Recovery Plan based on three axis: the European Green Deal, adaptation to the digital age, and a fair and inclusive recovery for all.

We must start investing in what makes our socio-economic system resilient to crisis. Now is the time to usher in systemic economic change and the good news is that we have our blueprint: it is the combination of UN Agenda 2030 (17 SDG) and European Commission’s European Green Deal. The European Green Deal (EGD) announced December 2019 is the new growth strategy of the European Union and is based on four principles: (a) climate neutrality by 2050, (b) protection of human life and biodiversity by cutting pollution, (c) world leadership in clean technology, (d) leave no one behind. The EGD Investment Plan amounts to EUR 260 billion per year by 2030. The EGD Just Transition Mechanism will help mobilize at least €100 billion over the period 2021–2027 in the most affected regions. The 2021–2027 Multiannual Financial Framework (MFF) allocates an overall target of 25% for climate mainstreaming across all EU programs. The proposed European Climate Law<sup>29</sup> aims to turn the EGD’s political commitment of 2050 climate neutrality, into a legal obligation. Based in UN Environment Program (UNEP) Emissions Gap Report 2019,<sup>30</sup> global emissions need to be reduced by 68% by 2030. Unfortunately, the proposed law does not include an ambitious goal with regards 2030 emissions, nor does it address the legislative interventions required to achieve climate neutrality by 2050.<sup>31</sup> Together with the EGD, the Sustainable Development Goals (SDGs) and the Paris Agreement call for deep transformations. While significant progress is being made on some goals, no country is currently on track towards achieving all SDGs.<sup>32</sup> Sachs et al. (2019) identify the major interventions needed to achieve each SDG and group them in six SDG Transformations, which operationalize the SDGs at government level and can prove instrumental for EGD implementation.<sup>33</sup> The success of the joint implementation of the SDGs, the EGD and the EU Recovery Plan will depend on the EU’s capacity to engage with its citizens in co-designing the pathways that will allow them to reach the 2050 vision, hence the introduction of the European Commission Climate Pact.<sup>34</sup>

<sup>28</sup> [https://ec.europa.eu/info/live-work-travel-eu/health/coronavirus-response/recovery-plan-europe\\_en](https://ec.europa.eu/info/live-work-travel-eu/health/coronavirus-response/recovery-plan-europe_en).

<sup>29</sup> European Parliament, Committee on Environment, Public Health and Food Safety draft report on the proposal for a regulation of the European Parliament and of the Council establishing the framework for achieving climate neutrality and amending Regulation (EU) 2018/1999 (European Climate Law), 2020/0036(COD). The review of the Climate Law summarizes the review of the Climate Change Committee of the Greek Ministry of Energy and the Environment, the first author of this paper is a member of this committee and co-author of this Greek review.

<sup>30</sup> United Nations Environment Programme (2019). Emissions Gap Report 2019. UNEP, Nairobi.

<sup>31</sup> The proposed Climate Law does not allow the European Commission to impose sanctions on Member States (MS), while there is lack of reference to the financial mechanisms that will be required to achieve the goal of climate neutrality. Moreover, the law does not consider (a) the well-documented heterogeneity in area-specific climate vulnerability among MS, (b) an EU wide carbon tax and (c) strengthening the European ETS.

<sup>32</sup> Sachs et al. (2020): The Sustainable Development Goals and Covid-19. Sustainable Development Report 2020. Cambridge: Cambridge University Press.

<sup>33</sup> (1) education, gender and inequality; (2) health, well-being and demography; (3) energy decarbonization and sustainable industry; (4) sustainable food, land, water and oceans; (5) sustainable cities and communities; and (6) digital revolution for sustainable development.

<sup>34</sup> [https://ec.europa.eu/clima/policies/eu-climate-action/pact\\_en](https://ec.europa.eu/clima/policies/eu-climate-action/pact_en).

## Conclusions

Recent generations, including the present, have experienced at least three global crises: the financial crisis 2007–2008, the ongoing COVID-19 pandemic and the developing climate crisis. If we continue attempting to address the latter two with the same socio-economic model that gave rise to the former crisis, we will fail to find a sustainable and resilient socio-economic–environmental pathway. *We believe that we can even do better than just react to crises by adapting to the new crisis-born reality.* We can use the integration of scientific, economic and socio-political knowledge to design policies which not only address the immediate impacts of the COVID-19 pandemic, but mitigate the existential threats of future pandemics and the ongoing and unfolding disasters of climate change, biodiversity loss and planetary boundary exceedance. What is needed now is a fundamental transformation of economic, social and financial systems that will trigger exponential change in strengthening social, economic, health and environmental resilience. We need big thinking and big changes. System innovation and transitions thinking can help but calls for intense public participation.

Now is the time, in addition to directing funds to the control of the epidemic and relevant biomedical research, as well as investing in border security, safe travel and safe trade, now is the time for financial institutions and governments to embrace EU taxonomy for sustainable investments (2020)<sup>35</sup> to phase out fossil fuels by deploying existing renewable energy technologies, eliminate fossil fuel subsidies and redirect them to green and smart climate mitigation and adaptation infrastructural projects, invest in circular and low-carbon economies, shift from industrial to regenerative agriculture and invest in food security, promote European supply chains, reduce transportation needs and exploit the limits of the digital revolution, while ensuring secure Information and Communication Technology networks.

A decisive march along this sustainable pathway will enhance economic and environmental resilience, create jobs, and improve health and well-being. The transition should be inclusive and “leave no one behind”, hence the need of transforming citizens into co-designers and co-owners of the sustainability transition pathways.

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## 10 Short-Windedness Would Weaken Effective Climate Policy

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Committing to rigid shutdown measures to contain the spreading of the corona virus has been undertaken on the tacit assumption that these measures will be temporary and can be loosened when the COVID-19 infection rates decrease and discontinued altogether once vaccines are available. Mitigating climate change and achieving ambitious temperature targets as set out in the Paris Agreement require a long-term structural change taking us away from our current carbon-intensive economy to a zero-carbon and then net-negative carbon economy. As current research holds out little hope that a “perfect” vaccine in the form of solar climate engineering will be available in the future, the measures and efforts required must translate into a permanent, ongoing form of commitment. While progressive climate change and the spread of the coronavirus operate on very different timescales, impatience about the duration of corona lockdown has indicated once more a fundamental problem for (long-term) environmental concerns. Clearly, the economic and social costs associated with the emergence of the virus and the shutdown are significant (Helm 2020, OECD 2020). But any serious cost–benefit analysis would need to take into account not only the fact that different degrees of lockdown are available but also that the overall cost is affected by the expectations of agents regarding possible future re-lockdowns due to insufficient containment of the virus. Seen thus, it is anything but clear at which point in time the actual cost of lockdown would have exceeded the economic cost of the virus spreading in an unmitigated (or insufficiently mitigated) way.

During the course of lockdown measures, voices calling for a “green” recovery stimulus package centring around low-carbon investments in the aftermath of the corona crisis have made themselves heard. By contrast, advocates of postponing climate mitigation-related taxes, levies, and regulations have also entered the fray, claiming that timely recovery should not be jeopardized by any additional economic burdens. The debate on the relation between (economic) recovery and climate policies has been conducted from three major perspectives. The first of these is largely notable for general statements of intent recommending that the recovery should be “green” and sustainable, that EU climate targets should be supported, and that other environmental targets (maintaining biodiversity, etc.) need to be taken into account when designing recovery measures. Such well-meant counsels as the statement issued by the German National Academy of Sciences Leopoldina (2020) are useful in reminding us that recovery from the corona crisis should not come at the expense of neglecting other objectives and that climate policy should not be backburnered, as was the case after the financial crisis in 2009. Otherwise, they are of little practical value.

The second approach has involved rather detailed proposals calling either for a “greening” of recovery by foregrounding measures to support renewable energies, public transport, energy efficiency, etc. or for a “blackening” of recovery by postponing and/or abandoning climate measures and environmental regulations. Predominantly, these proposals are representing the positions of the various interest groups involved. For example, representatives of the aviation industry try to prevent the harmonization of carbon prices on fuels with respect to kerosene and argue against the introduction of kerosene taxes. This idea resurfaces in the

discussion on recovery measures by, say, the Austrian Aviation Association (2020). On the other hand, in its comprehensive list of (recovery) demands, the NGO German Environment Action (2020) urges for example for the abandonment of blue hydrogen projects (though not explaining why this is likely to stimulate economic recovery). Various other interest groups are in favour of postponing, suspending or even abandoning existing environmental and climate regulations. For example, Janusz Kowlaski, the Polish Deputy Minister of State Assets urges "...[that] the ETS [European Emissions Trading Scheme] should be removed from January 1, 2021 or at least Poland should be excluded from the system".<sup>36</sup> Clearly, there is no point in discussing nonsensical ideas of this kind. But some of these proposals also make sensible suggestions like adjusting the German cap on renewable energy installations or abandoning the EU average fleet-consumption regulation because the former contradicts German renewable energy targets and the latter is an inefficient instrument for regulating vehicle emissions. However, these suggestions do nothing to provide stimulus for a quick recovery. While specific processes and regulation timelines for regulations may need to be adjusted in the context of the corona crisis, sensible measures of this kind should be discussed and decided upon in the regular political process. Confining potential stimulus and recovery measures to their proper purpose does not mean imposing a ban on meaningful (climate or environmental) policies that are not associated with the corona crisis.

The third and most sensible perspective replaces specific proposals with (sustainability) assessment guidelines like those suggested by the World Bank (2020). While hardly any possible recovery measure would perform well against the comprehensive list of criteria provided by the World Bank, such guidelines are helpful in arguing against interest group driven proposals. The World Bank has suggested that potential measures up for consideration as part of a recovery strategy need to be assessed against both, short- and long-term criteria, an example for the former being the expected economic multiplier associated with certain measures. Bayer et al. (2020) suggest that income transfers (as planned under the US CARES package) perform well against this specific short-term criteria: they could help to stabilize private-sector spending and the multiplier could increase to 2 in the case of transfers being conditional—but not related to emissions but to the propensity to consume, i.e. conditional on being unemployed. However, private-sector spending like this should not imply any unintended adverse effects on essential long-term structural change that might arise from such things as (temporarily) adjusted risk preferences. Once postponed or stimulated demand and investment take place during the recovery process, carbon-price signals are vital in providing technology-neutral incentives for low-CO<sub>2</sub> purchasing and production decisions.

Overloading stimulus or recovery packages with too many (emission-related) conditions performs poorly against the short-term criteria with respect to a timely recovery. Even worse, the inclusion in recovery packages of various detailed suggestions from the various interest groups usually results in a non-transparent, rent-seeking, and political bargaining process in which it remains unclear whether (sensible) individual emission-related decisions are being prioritized at the expense of a more challenging long-term climate policy. Accordingly, accounting for the long-term criteria requires that existing or planned climate policies providing incentives for emission reductions and technological innovation should remain in place and not be postponed, let alone weakened. Otherwise, uncertain (short-term) recovery impulses most likely come at the cost of less efficient emission-reduction paths in the long term.

<sup>36</sup> <https://www.reuters.com/article/us-health-coronavirus-poland-ets/eu-should-scrap-emissions-trading-scheme-polish-official-says-idUSKBN2141RC>.

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## 11 COVID-19 and Climate Change: Should Governments Tie Corporate Bailouts to Environmental Efforts or Strengthen Current Environmental Policies?\*

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### 1. Introduction

The coronavirus pandemic is having a serious impact on the economy. Eurostat estimates that seasonally adjusted GDP decreased by 3.5% in the EU during the first quarter of 2020, compared with the previous quarter. In certain sectors, the COVID-19 crisis has led to the



temporary or even permanent closure of sites, a collapse in demand and an increase in production costs linked to the fight against the spread of the virus. This decline in activity can trigger bankruptcies, which result in unemployment and the destruction of physical and human capital, leading in turn to a loss of specific knowledge and skills and to market concentration and the partial relocation of production activities. From an environmental point of view, bankruptcies and relocation may generate higher emissions by increasing production in more polluting sites abroad and by increasing the transportation of goods. In addition, the decline in economic activity may have a negative effect on research and development spending, which is crucial for future growth and the development of more environmentally friendly technologies.

Many measures have been put in place to limit the economic effects of the COVID-19 crisis. At the European Union level, a number of measures such as direct subsidies, selective tax benefits, advance payments, state guarantees for loans and subsidized public loans to companies have been implemented. In addition, many large companies are being bailed out and there is a debate on whether conditions should be attached to this state aid. These conditions could relate to various commitments such as relocating activities,<sup>37</sup> paying taxes,<sup>38</sup> safeguarding employment, and protecting the environment. On 8 May 2020, the EU confirmed that large companies receiving emergency cash during the COVID-19 crisis will not be obliged to devote funds to “greening” their operations. Rescued firms will only have to report on their use of the aid and in some cases the aid could be attached to conditions such as a ban on dividends and management bonus payments. Nevertheless, member states are free to design national measures in line with additional policy objectives, such as further enabling the green transformation of their economies. Many stakeholders are still pushing for conditions to be attached to the bailouts. For instance, the EG3 think tank proposes making the rescue of airlines conditional on the use of less polluting fuels and tying aid to car manufacturers to the development of electric vehicles. A group of German companies has also requested that state aid be linked to climate actions.<sup>39</sup>

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<sup>37</sup> For example, the 8 billion euro rescue plan for Renault requires electric vehicle production and assembly to be located in France.

<sup>38</sup> Transparency International EU believes that EU decision makers should ensure that companies receiving national or EU-level bailouts explicitly confirm that they will not artificially shift profits to tax havens and that they declare their profits where the economic activities take place. The organization explained its position on its website in “Why business bailouts must be conditional on responsible tax commitments” on 12 May 2020.

<sup>39</sup> This statement was released by ThyssenKrupp, Salzgitter, Bayer, Covestro, E.ON, HeidelbergCement, Puma, Allianz, and Deutsche Telekom and reported by Reuters on April 27, 2020, in “German companies call for COVID-19 aid to be tied to climate action”.

This article examines the merits of making aid conditional on environmental efforts. We focus on the rescue plans for companies rather than on recovery plans or the European Green Deal, which was launched before the COVID-19 crisis. We show that tying aid to environmental efforts is difficult to implement and requires both controls and sanctions, as well as a large amount of information. We also discuss the merits of tying bailouts to environmental efforts compared with implementing more stringent environmental policies (presuming that companies will be bailed out in any case).

## 2. Acceptability of Environmental Policies

Since environmental efforts can lead to higher product prices and lower profits, two dimensions of acceptability must be taken into account: acceptability from the point of view of companies and social acceptability.

Acceptability of environmental policies by companies is a necessary condition for their implementation. In the midst of the current crisis, many polluting industries are lobbying to weaken and delay environmental regulations.<sup>40</sup> For instance, the Environmental Protection Agency issued a sweeping suspension of its enforcement of environmental laws, allowing companies to breach environmental standards during the coronavirus outbreak. In Indonesia, the trade ministry revoked rules requiring basic certification that wood exports were legally produced, in response to lobbying from the furniture and logging industries.<sup>41</sup> Lobbyists may also encourage legislators to compensate companies for losses related to environmental regulation.<sup>42</sup> The implementation of rescue plans, by providing aid and guarantees, could be a tool to make environmental efforts more acceptable for firms.

Acceptability by society is also central. It depends on the redistributive effects of environmental policies, especially since they are often regressive. In France, the “red caps” and “yellow vests” movements illustrate the difficulty of implementing such policies. Both of these movements led to the cancellation and delay of environmental policies (eco-tax applied to heavy vehicles and carbon tax, respectively). The COVID-19 crisis may affect societies’ support for more ambitious environmental policies. Several observations can be made. First, it appears that there is a confirmation bias, as countries and NGOs that had already committed to fight against global warming want to intensify efforts, while countries that were already recalcitrant are calling for a decrease in efforts in the light of the economic crisis.<sup>43</sup> Second, the COVID-19 crisis makes the risk of disaster more salient and vivid and may therefore increase the demand for stronger environmental protection. As explained by Sunstein (2006), if a particular risk is cognitively “available” then people will have an increased fear of the risk in question. Finally, the crisis has revealed that populations will accept drastic measures (lockdown, wearing face masks) and a rapid change in social norms (social-distancing, for instance), which shows the ease with which individuals could adapt to more ambitious environmental policies.

<sup>40</sup> See Oates and Portney (2003) for a literature review of interest groups and environmental regulation.

<sup>41</sup> “Polluter bailouts and lobbying during Covid-19 pandemic”, *The Guardian*, April 17, 2020.

<sup>42</sup> Burkey and Durden (1998) and Joskow and Schmalensee (1998) have detailed how firms can influence the regulator’s decisions in the context of pollution rights markets, while Bovenberg and Goulder (2001), Hepburn et al. (2013) and Nicolai (2019) have shown that few permits are sufficient to neutralize the losses in profits and make the implementation of pollution permits acceptable.

<sup>43</sup> On March 16, the Czech Prime Minister, Andrej Babis said that the European Green Deal should be put to one side. During the same period, the Green 10 coalition of environmental organizations organized an appeal urging lawmakers to design a green, healthy and just recovery.

### 3. The Design and Monitoring of Environmental Conditions

We study two possible ways of increasing environmental efforts: making aid to companies conditional on environmental efforts or making existing environmental policy more stringent.

Making aid conditional on efforts to protect the environment can take different forms. Commitments may relate, for example, to reducing pollutant emissions, using less polluting production processes, increasing expenditure on research and development, and producing less polluting products. For instance, in France, Renault's bailout requires it to increase the share of electric vehicles, while the 7 billion euro Air France bailout imposes the use of at least 2% of alternative jet fuel by 2025, a target of 50% emissions cuts by 2030, and a 50% decrease in domestic flights by 2024, especially those that compete with high-speed trains.<sup>44</sup> Conditional aid as currently envisaged is equivalent to negotiating and implementing individualized standards on technology, final products, research and development efforts, emissions and performance for each company.

The first question that arises is how to determine the conditions. Conditional bailouts allow the regulator to individualize the standards applied to a particular firm, making it possible to set the most appropriate instrument and the optimal level of severity for each firm. When making its decisions, the regulator should consider the possibility of a rebound effect as explained by Saunders (1992). An emissions standard may avoid such an effect, but a standard on technology may increase emissions. Furthermore, the regulator should take into account its access to information. If the firm commits to finance research and development in green technology in exchange for being bailed out, it will be hard for the government to determine whether the state aid was actually allocated to research. For example, since the results of research are uncertain, a lack of innovation may be explained either by the firm's characteristics (anti-selection problem) or by the misallocation of public funds (moral hazard problem).

Finally, the regulator should take into account competition, since firms receiving bailouts usually have market power. A government will mainly intervene to save a firm if its bankruptcy would have a significant effect on the economy. The government should hence ensure that the conditions do not further distort competition. A firm with a competitive advantage, for example with cleaner technology, may have an interest in advocating more ambitious environmental efforts for itself but also for its competitors in order to increase its market share by preventing the entry or inducing the exit of such competitors.<sup>45</sup> The effectiveness of conditions will therefore depend on the type of commitment, competition in the market, and the demand elasticity of the final good.

Another question relates to the duration of the contract. Some actions are reversible and after a certain period of time companies can cancel or amend them. For example, the use of cleaner but more expensive inputs is an easily reversible strategy, while a shift in production, for example from internal combustion vehicles to electric vehicles, is a more expensive choice to change. In addition, research and development efforts produce long-term

<sup>44</sup> "KLM's coronavirus bailout still waits for takeoff", Euroactiv, May 7, 2020.

<sup>45</sup> For instance, Puller (2006) shows how firms can act strategically to make standards more stringent in order to raise their rivals' costs, while Heyes (2009) shows that incumbents can prevent certain firms from entering the market.

effects with the creation of innovations and possible technological spillovers. The duration must therefore be individualized in function of the company's characteristics.

It should also be noted that conditional aid can lead to windfall gains. Some companies had already planned emission reductions and changes in strategy. These decisions were aligned with the companies' interests.<sup>46</sup> If the company benefits from the environmental efforts put in place, these can no longer be considered as a counterpart to the company's bailout and the company should then make greater efforts.

It seems clear that the success of such schemes lies in companies' compliance with the commitments. Companies may nonetheless have an interest in not complying with them. It is therefore necessary to monitor companies' implementation of the commitments and to sanction those that fail to honour them. Supervision costs will thus be incurred.<sup>47</sup> One possibility for alleviating control costs is to publicly announce the commitments, which facilitates the monitoring of companies' commitments by society (e.g. by journalists, politicians and non-governmental organizations). This also gives the firm a further incentive to respect the agreement in order to maintain its reputation and to retain its customer base (Heyes et al. (2018) and Heyes and Kapur (2012)).

We now focus on the sanctions to be applied in the event of non-compliance with the commitments. Various penalties could be considered, such as financial penalties, a ban on applying for the attribution of public contracts and the state's participation in the company. The sanctions must be explicit, credible and sufficiently significant to discourage companies from breaking their contracts. However, given the current economic situation and the fragility of companies, governments should be cautious when using financial penalties or bans from participating in public contracts since, if effective, they could be fatal to companies. An alternative could be for the state to take a share in the company in the event of non-compliance with commitments. Such shareholdings would make it possible to influence companies' strategic choices, but they raise efficiency problems. Cavaliere and Scabrosetti (2008), Schmidt (1996) and De Fraja (1993), for instance, highlight two effects: production is more efficient in privatized firms because better incentives can be given to managers and employees (productive efficiency), while public firms are more socially efficient because the government cares about social welfare and internalizes externalities associated with firm liquidations (allocative efficiency).

#### 4. Increasing the Stringency of Environmental Policies

Existing environmental policies inevitably generate monitoring costs; however, these costs will be borne in any case. Increasing the stringency of environmental policy involves determining new levels for existing instruments, which generates costs, but there will be no additional monitoring costs. Moreover, opting for a more stringent environmental policy means that market-based instruments can be employed, which is not feasible in the first strategy. Due to the principle of non-discrimination, it is unlikely that individualized taxes could be introduced under the negotiated bailout conditions.<sup>48</sup> Environmental economists agree that these instruments are more effective than command-and-control instruments

<sup>46</sup> The Porter hypothesis states that companies can increase profits with the implementation of environmental policies (Porter (1991)).

<sup>47</sup> There is an extensive literature on optimal control strategies. See, for instance, Millock et al. (2002) and Colson and Menapace (2012).

<sup>48</sup> In 2009, the French Constitutional Council ruled against the proposed carbon tax on greenhouse gas emissions as it violated the equality principle, since most industrial emissions would be exempt.

since they have the potential to generate revenue and allow for a double dividend, provide incentives to invest in clean technology and require less information to be designed. Nevertheless, making aid conditional on environmental efforts makes it possible to individualize the regulatory instruments for each firm, which is not possible in the context of market-based instruments. The positive effect of the instrumental individualization induced by conditionality only materializes if the existing environmental policy is based on command-and-control instruments. With market-based instruments, individualization is not required to achieve an efficient outcome, whereas it is necessary in the case of command-and-control instruments.

Companies' negotiation power is an additional argument for increasing the severity of environmental policies rather than conditioning bailouts on environmental efforts. Regardless of the policy, firms may use their bargaining power to mitigate the stringency of the regulation or the effort they commit to make. It is clearly easier for a firm to influence its specific negotiated conditions, which are one-on-one relationships, than to influence environmental policies, which would require coordination and a common interest among firms. Furthermore, making environmental policy more stringent will affect all companies and not only those receiving bailouts, which increases the attractiveness of this strategy. Since they apply to a larger number of companies, these more restrictive policies will have a greater effect on the environment.

## 5. Conclusion

To conclude, this note analyses the advantages and disadvantages of making bailouts conditional on environmental efforts. We show that such a system could be beneficial for the environment and would be a counterpart to bailing out companies. However, it is costly, requires a large amount of information, and is less efficient than increasing the stringency of existing environmental policies. On the other hand, making aid conditional on environmental effort is more acceptable from the companies' point of view than increasing the severity of environmental policies. Companies would rather commit themselves to environmental efforts than pay taxes or buy permits in order to minimize compliance costs. To succeed in making environmental policy more ambitious, the regulator needs the support of society to compensate for companies' reluctance. If there is strong public support, governments should not negotiate conditional aid but should increase the severity of environmental policies. They can integrate such actions into recovery plans or, in the case of the European Union, into the revision of the Green Deal. It is therefore particularly important to study how the COVID-19 crisis has changed society's perception of the need for more stringent environmental policies. For instance, a recent survey by IPSOS<sup>49</sup> shows that three out of four people in 16 major countries expect their government to make protection of the environment a priority when planning a recovery from the coronavirus pandemic, although there is considerable heterogeneity across countries.

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## 12 Climate and Energy Policies After COVID-19

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The post-COVID-19 reality is changing the context of most policies, including those in the fields of energy and the environment. The EU Green Deal objectives should be maintained but concrete policies may have to be adjusted to this new reality.

A major energy transition is under way, shaped by political will to tackle climate change. Policies have been defined under the Paris Agreement and geared to a number of targets. The EU has decided to reduce its greenhouse gas emissions by 2030 by at least 40% compared to 1990 and has agreed to continue the path towards climate neutrality by 2050.<sup>50</sup> The immediate recession following the COVID-19 crisis drastically reduced energy consumption and greenhouse gas emissions (Le Quéré et al. 2020). The sudden decline in greenhouse gas emissions is the opposite of what a meaningful response to climate change should be, in terms of both quality of life and economic efficiency. The challenge is to structurally decouple economic growth from emissions, not to have them both going down.

The lockdown may have some lasting effect in changing some of our habits (Hepburn et al. 2020), e.g. a generalized familiarity with telework. One can also expect a more general reflection on whether all business and leisure travel, not least by air, is necessary. Nevertheless, many changes may not be as extensive and lasting as some would wish. For this reason, it is important to integrate a climate check into the stimulus packages that governments and European institutions are currently designing.<sup>51</sup> The current health crisis and the likely economic downturn could be seen as an unsolicited—and much regrettable—opportunity towards a carbon-neutral future (Kåberger and Sterner 2020; Koundouri 2020). The agreements reached in the context of the Eurogroup,<sup>52</sup> the latest turn in the European budgetary discussions, as well as the statements by the Commission President all point into this promising direction.

The EU Green Deal has confirmed the EU Emissions Trading System (ETS) as a key element and the price of EU allowances serves as a key indicator worldwide. As could and should be expected, carbon prices have fallen during the lockdown reflecting reduced demand for allowances in line with the drop in power and industrial production. This temporary drop from the €25 to a €15–20 range,<sup>53</sup> acts as an important automatic stabilizer for businesses in distress. A repetition of the experience of a sharp fall in the

<sup>50</sup> See on this issue the important draft report prepared by the European Parliament Committee on the Environment, Public Health and Food Safety (European Parliament, 2020).

<sup>51</sup> <https://lifedictproject.eui.eu/2020/04/08/covid-19-climate-policy-and-carbon-markets/>.

<sup>52</sup> <https://www.consilium.europa.eu/en/press/press-releases/2020/04/09/report-on-the-comprehensive-economic-policy-response-to-the-covid-19-pandemic/-point21>: “Work is ongoing on a broader Roadmap and an Action Plan to support the recovery of the European economy through high quality job creation and reforms to strengthen resilience and competitiveness, in line with a sustainable growth strategy”.

<sup>53</sup> <https://ember-climate.org/carbon-price-viewer/>.

price of EU ETS allowances after the 2008 recession and a long period of very low-carbon price levels should be avoided. There are two reasons to believe that this could happen: (i) the EU ETS now has a Market Stability Reserve (MSR) operating in the short–medium term and (ii) long-term market expectations could be shaped by the 2050 carbon neutrality objective.

The MSR started to operate last year and absorbs a potential oversupply in the market in the short and medium term. If the allowances market is “long” beyond a threshold set in legislation (833 million tons, which is approximately 50% of ETS emissions in 2018), the MSR intervenes by withdrawing allowances equal to a percentage (24% up to 2023, 12% thereafter) of the excess. At the end of 2018, the allowance market was 1.65 billion tons “long” and, therefore, the supply of allowances for the period 1 September 2019 to 31 August 2020 has been reduced by 397 million tons (these allowances are placed in the MSR). Some question whether the MSR, with its delayed adjustment mechanism, will be sufficient to avoid a sharp fall in the allowance price (cf. Flachsland et al. 2020). In fact, any reduction in the supply of allowances through the MSR for the period September 2020–August 2021 will still be based on the excess supply of allowances in 2019, i.e. before the current crisis started. In case the MSR is unable to absorb the surplus, the EU Commission should propose changes in the planned review of the ETS in 2021.

Long-term expectations might overtake this short-term risk. In its European Green Deal, the Commission already indicated its intention to tighten the 2030 greenhouse gas emission reduction target from 40% to 50%, or even 55% (with respect to 1990 levels). Today, the ETS sectors face a mandatory emission reduction of 43% by 2030 compared to 2005, and revised targets will likely increase that obligation by at least another 10 or 15%. Such a reduction in the supply of allowances would likely push their prices up, or at least reduce the extent of their decline, in the face of lower demand due to the economic downturn. Therefore, carbon market participants as well as those developing innovative clean technologies and products of the future are likely to expect significantly higher carbon prices in the future. This raises the question about a possible loss of competitiveness in Europe’s traditional industries vis-à-vis competitors located in countries where no similar burden is imposed. Some proposed a border adjustment, which would imply both a levy on imports and possibly a rebate on exports. However, such mechanisms are not easy to implement and are subject to criticism on both analytical and political grounds. Therefore, it is of crucial importance to realize that a WTO-compatible border adjustment mechanism will take some time before it can be implemented. Meanwhile, at least equal attention needs to go to domestic policy reinforcement, such as support for innovation and a less rigid interpretation of the state aid rules.

Governments and European institutions are currently developing a major investment stimulus package. The Commission’s impact assessments on climate and energy policy serve as useful guidance on where a major surge in investments is needed. We know that energy efficiency requires a major push in the construction sector, both for new buildings and renovations in social housing, hospitals and schools. We know that the energy transition requires more investments in renewable energy, digitised grid infrastructure and energy storage. The significantly reduced electricity demand of today indicates that much more attention should go towards managing flexibility in real time instead of increasing baseload capacity. In transport, electrification is on its way, but investment in charging facilities, traffic management, clean public transport and long-distance rail needs to be ramped up. In industry, not least in power generation and carbon intensive industrial sectors, major efforts are being undertaken to develop new technologies based on hydrogen and carbon capture,



use and storage, for example. Such investments can create the jobs we need in the post-COVID-19 era and allow to realise the EU Green Deal objectives at the same time.

Apart from carbon prices and investment support schemes, it remains of equal importance to maintain a consistent energy price signal throughout the economy. However, the recent fall in the prices of fossil fuels is upsetting the incentives that should support a transition towards sustainability. A reference criterion for economic decisions has been lost and the consequence may be a paralysis, or even a “comeback” of fossil fuels, mothballing or abandonment of investment in renewables. Consequently, the business case of the green transition may appear to be weakened in the near term, but a clear policy response may be politically more acceptable because of the price drop in fossil fuels. This raises the question about the other half of Europe’s emissions, namely those not covered by the ETS, in particular the sectors of transport and buildings. The pricing of these emissions can be much improved through the planned review of the EU’s energy tax directive. This offers a major opportunity to remove the all too generous exemptions, such as on maritime and aviation fuels, or by adding a CO<sub>2</sub> element to the harmonized minimum tax rates. In such a manner, prices of fossil fuels could be stabilized at the pre-COVID levels via temporary taxes, whose revenue could help finance the various income-support policies adopted and/or an acceleration of investment projects for sustainability. In this way the EU should better prepare for a long period of low oil and gas prices and seize the opportunities these can offer.

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## 13 Killing Two Birds with One Stone? Green Dead Ends and Ways Out of the COVID-19 Crisis

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Public measures to combat the COVID-19 pandemic have led to a severe economic crisis. In order to cope with this crisis, comprehensive government aid is being requested. Accordingly, governments across the world have pledged billions of Euros for extensive recovery programs. One of the main questions debated in this context at the moment is how “green” these recovery programs should be (Helm 2020; Hepburn et al. 2020).

### The Coronavirus Crisis as a Moment for Interest Groups

The expectation of huge amounts of public money being distributed at short notice brings interest groups of every shade to the scene—preferably with old wish lists on hand. Consequently, there is a big risk that recovery programs will be captured by interest groups (for an overview of the literature on regulatory capture, see Dal Bo 2006). On the one hand, climate change mitigation is put under pressure as being an “extra burden” for industries. For example, European car manufacturers have called for postponing the upcoming tightening of EU emission standards for car fleets (Topham and Harvey 2020). Some EU Member States call for stalling the EU Commission’s plan of a European green deal (Simon 2020). On the other hand, many recommend spending the public money mainly on measures that also help mitigating climate change—among them Frans Timmermans, Executive Vice-President of the European Commission (Schulz 2020), or Fatih Birol, head of the International Energy Agency (Birol 2020).

There is one thing that must not be overlooked in this politico-economic competition: public funds are still short and must be used reasonably. Otherwise ill-designed (green) subsidies can quickly turn into a part of the problem instead of being the solution. Previous “Cash for Clunkers” programs warn as an example of a misguided recovery measure. These programs were introduced in many countries after the 2009 financial crisis and provided financial incentives to trade old, less fuel-efficient cars for new, more efficient ones. Empirical analyses have shown very mixed results regarding both the economic and the environmental stimulus effects of these measures (Grigolon et al. 2016; Li et al. 2013; Mian and Sufi 2012). At the beginning of every discussion about (green) recovery programmes, it is therefore important to develop transparent and sensible criteria based on which public aid should be allocated.

### Recovery Programmes Must be Climate-Proof

After the initial bail-out programmes, public recovery programmes to stabilize the economy are now debated politically. Certainly, this generates an unprecedented window of opportunity for structural transformation. Moreover, the distribution of public aid may also justify committing beneficiaries to public interests to a certain extent. Consequently, the currently available political degrees of freedom should be used to promote

the transition of society towards sustainability. Subsidies to branches like tourism, aviation and agriculture—which are particularly hit by the crisis and are lagging behind in terms of sustainability—should be paid conditional on meeting minimum environmental standards. New investments into long-lived, fossil-fuelled assets must be avoided. A recovery program cannot only be about re-establishing the status quo ante by assigning large public funds, possibly creating new barriers for sustainability transitions. In this respect, it makes sense to implement recovery programs that are in line with the objective of mitigating climate change—as called for by many at the moment. However, such green recovery programmes must not be arbitrary.

### **Broadband Green Subsidy Programmes are Not the Solution**

Green recovery programmes must go beyond green subsidies. First of all, it is also important to reduce unnecessary barriers for green investments, for example by revising legal constraints to the expansion of renewable energies like solar photovoltaics or wind power. Moreover, any green recovery program can only effectively and efficiently spur decarbonization if it combines with a carbon price and the abolition of environmentally harmful subsidies. The direction of recovery must be crystal clear. Otherwise green subsidies risk being ineffective and costly approaches to mitigating climate change (Kalkuhl et al. 2013; Palmer and Burtraw 2005), while imposing additional burdens on public budgets and reducing political degrees of freedom in the future. For subsidies to be economically justified, they need to meet clear criteria.

### **Green Stimuli Must Help Stabilize the Economy**

For green recovery programs to succeed in the competition for public funds with other important policy fields (such as health or digitalization), they must help stabilize the economy. Moreover, policy makers need to be aware that some of the currently observed economic problems might even resolve without any government aid. It can be expected, for example, that global supply chains will resume and that people will catch up on purchasing durable goods like cars, at least partly. It is exactly (the maintenance of) environmental regulation that may help steer this consumption towards more sustainable modes.

Government interventions must take effect where permanent disruptions are looming. One example: Innovative green business models may particularly be at risk if banks limit loans in the presence of the current uncertainties (Lehmann and Söderholm 2018). In this case, government loans may provide direct assistance. In contrast, attempts to lower prices for goods and services—e.g. for cars (VAT reduction, purchase premiums) or electricity (reduction of energy levies)—are rather inappropriate means to stabilize the economy. Such measures fail to address the actual sources of insufficient investments or reduced purchasing power, and are therefore inefficient ways of spending public budgets. Furthermore, it is unclear whether and to what extent such discounts will be passed through to final consumers by market prices (Peltzman 2000).

### **Green Stimuli Must be Checked for Mitigation Potential and Maturity**

Green recovery programs should focus on government interventions that would also have been economically reasonable without the COVID-19 crisis—for example, to correct market failures next to the CO<sub>2</sub> externality (Benbear and Stavins 2005; Fischer and Newell 2008; Lehmann 2012)—and that have the highest priority for climate policy. Moreover,

those measures should be implemented for which rational concepts have been drafted already and that can be realized promptly. Positive examples of such “no-regret measures” can be found in the transport sector, for instance. This sector is severely lagging behind in terms of climate change mitigation, and economic rationales for public expenditures exist at least partly (Briggs et al. 2015; Low and Astle 2009). In addition to that, numerous actors have already developed elaborated programmes of measures. Those measures that can be implemented quickly, should now be launched—for instance to electrify the transport sector or to strengthen public transport.

### **Polluters Should Contribute to Funding Green Recovery Programmes**

(Green) recovery programmes must not only address the expenditure side. A currently still disregarded issue is the question how the required billions of Euro could be raised. Public expenditures for a green recovery program should at least partly be funded by polluters by implementing a carbon price and abandoning ecological harmful subsidies. Such policies internalizing environmental costs would not be an extra sacrifice—but rather part of the solution both for revenue problems and for the redirection towards sustainability (for a review of the double-dividend hypothesis, see Goulder 2013).

### **Conclusion: Combine Economic Stabilization, Mitigation of Climate Change and Revenue Raising**

The coronavirus crisis has opened up a window of opportunity for transformation. This should be used without getting off the regulatory track. Green recovery programs must not be reduced to a mere competition for green subsidies. Abandoning barriers to green investments and imposing a carbon price are equally important. Where economically sensible, green subsidies should contribute to both stabilizing the economy and mitigating climate change. Moreover, smart green recovery programs may contribute to raising revenues for the additionally necessary public expenditures.

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## 14 COVID-19: Disruption of Local Food Supply Chains Could Hamper Sustainable Agricultural Practices

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### 1) Introduction

The world is currently facing the largest pandemic since Spanish flu in 1918. This has led to a lockdown policy on an unprecedented scale and measures of social distancing that are expected to continue. In France, as elsewhere, the “Great Lockdown” has disrupted food production chains through simultaneous shocks to demand and supply. Populations have seen their food consumption habits be severely modified (e.g. closure of restaurants and

markets). Fearing food shortages, consumers have often stockpiled basic necessities, which has led them to actually provoke shortages, albeit temporarily. Food production has also been disturbed, most notably by the reduction in the available workforce, whether domestic (due to the lockdown, illness or childcare) or foreign (temporary closure of borders). The issues at stakes are numerous, including deglobalization and environmental impacts, in both the long and short terms (Helm 2020). The pandemic will lead to unprecedented uncertainties in food supply chains.

In addition to the health crisis, a dramatic drop in worldwide GDP is anticipated—approximately 3%—with a partial catch-up in 2021, according to the International Monetary Fund (IMF 2020). The reduction in income will soon impact food consumption. Some authors are already pointing to an increase in social inequalities. The most fragile populations could slide into severe food insecurity, including in developed countries, as shown by Deaton and Deaton (2020) for Canada and Power et al. (2020) for the UK. However, the FAO is rather reassuring about the total volume of food (cereal) at the global level. It also notes that the world price index has fallen in recent months. This does not necessarily mean that this decline is effective regardless of the type of agricultural production. In particular, fruits and vegetables could become more expensive.

Agriculture is by nature a risky activity, and the adoption of eco-environmental practices can only increase this risk. As a consequence, organic farmers, for instance, could be particularly affected by the combination of health and economic crises. The cost of organic production is therefore structurally higher, which could pose a problem in the event of an income shock. To add value to their production, many small farmers combine organic farming with short food supply chains. This makes it possible to regain a more comfortable margin than that allowed by mass distribution. However, here again, the health crisis has profoundly changed marketing channels. While supermarkets were stormed with shoppers at the beginning of the crisis, some short channels were closed, such as markets and restaurants, to preserve social distancing.

This article therefore considers the consequences of COVID-19 for sustainable agricultural practices, particularly for farmers who have chosen organic farming in short supply chains. To do so, we use the multi-level perspective (Geels 2002) approach to conceptualize socio-economic transitions.

## **2) The Multi-level Perspective: An Analytical Framework for Sustainable Transition of the Agri-food Regime**

The multi-level perspective (MLP) approach analyses transitions as mutation processes from one socio-technical regime to another under the pressure of macrolevel forces and the emergence of market niches that could provide the basis for a new regime (Geels 2002). We show here why local food supply chains are perceived by some farmers—especially the smallest—as a way to enhance the economic value of eco-friendly agricultural practices, such as organic farming.

In France, the current dominant socio-technical regime based on conventional agriculture emerged gradually in the 1950s. Conventional agriculture diffuses slowly at first because of the high investment costs. However, the French state and farmers' unions support it as a means of increasing production and improving living and working conditions. Farmers are then inclined to take on more debt and become dependent on their suppliers (phytosanitary products, seeds, tools, etc.), the food industry and supermarkets. As a result, this modernization of agriculture has been controversial from the outset, at least with regard to farmer autonomy and the country's food sovereignty (Levidow et al. 2014).

The early development of organic farming in France began in the 1980s due to the effects of three negative effects of conventional agriculture, namely pollution, soil impoverishment and the lack of autonomy mentioned above. The organic label has become a marketing argument that is profitable for large farms, since they achieve significant scale effects on these standardized products. Large scale organic farming is therefore less demanding and, by its nature, allows to benefit from the effects of scale. This is new competition for small farmers struggling to differentiate themselves. The organic label itself does not allow farmers to free themselves from the pressures upstream and downstream in the production chain.

To differentiate themselves from large organic farms, some farmers are starting to sell in open-air markets again. At the same time, the idea that fair trade can concern North–North relations and not only North–South relations is beginning to emerge, which favours the development of community-supported agriculture. A new initiative is gradually emerging: collective farmers' shops. These initiatives began, for example, in the south of France in the mid-1980s and represent a more important restructuring of the farmers' market.

### 3) Looking Ahead and Lessons from the Pandemic

In the medium term, the drop in income could increase the consumption of basic necessities (Giffen goods) to the detriment of organic products. Everything will depend on the elasticity of the demand for these products. Until now, organic products have been extremely popular. It is possible that "industrial organic" will take market share from a "more artisanal organic" if consumers still want to consume organic products but cannot afford to spend a large part of their budget on them.

Farmers in short supply chains often have several distribution channels simultaneously, especially market gardening farmers. This allows them to be more responsive to demand. Thus, the closure of farmers' markets and restaurants can be compensated for by farm shops, community-supported agriculture (CSA), fixed point or home delivery, or collective farmers' shops.

Regarding hygiene measures, farmers are faced with two main types of strategies: receiving customers in the original locations or digitizing the process, including the more marginal case of automatic food dispensers (e.g. for eggs). Selling in physical places must respect social distancing, which discourages consumption. However, conserving this method makes it possible to maintain the relational proximity between farmers and consumers. Initially, this relational proximity is one of the main arguments in favour of short supply chains, as it is supposed to allow better traceability of products and to fight against social isolation (especially of the elderly).

The other strategy, therefore, is to limit direct contact between human beings by means of computer tools. Internet platforms already existed before the crisis and are expected to develop. Some were public, such as those set up to supply school canteens. The pandemic has accelerated this process, and some regions have launched their own platforms. This solution is very time-consuming and seems difficult to sustain, unlike the others, which should have an impact in the long term. Another practice has been reinforced: farm shops. During the lockdown, some consumers presumably had more time to cook and go to farms. Others fled from supermarkets, considering that the products were handled by a large number of people and that there was too much traffic. It is difficult to predict whether these changes in behaviour will have a long-term impact.

In addition, the pandemic has raised concerns about the reliability of international distribution channels. It is therefore possible that some policies may be sensitive to the

issue of food sovereignty and seek to reinforce the relocation of part of the food supply chains. Of course, it is not a question of valuing protectionist policies at all costs. In contrast, in addition to raising prices (French labour is expensive), this would make the national food system more vulnerable in the event of poor harvests (droughts, floods, etc.). However, to be truly effective, relocation would require profound changes to the French food system, for example, reducing the production of meat and cheese, which are heavily dependent on soybeans. Both environmental (greenhouse gases and biodiversity) and social (food sovereignty, profitability of small farms) objectives are compatible here. Finally, the short food supply chains therefore represent a radical change to consumption that would not be acceptable to the majority of consumers currently but would help farmers retain their customers and challenge the agri-food regime.

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## 15 The Challenge of Using Epidemiological Case Count Data: The Example of Confirmed COVID-19 Cases and the Weather

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The publicly available datasets on confirmed COVID-19<sup>54</sup> cases and deaths provide a key opportunity to better understand the drivers of the pandemic. Research using these datasets

<sup>54</sup> In this article, we follow Xu et al. (2020) who define COVID-19 cases as individuals for whom SARS-CoV-2 has been detected using RT-PCR.



has been growing at a very fast pace (see an indicative list of references in supplementary material 1). However, little attention has been paid to the reliability of this type of epidemiological data to make statistical inferences.

Our initial aim was to produce a detailed statistical analysis of the relationship between weather conditions and the spread of COVID-19. This question has attracted significant attention from the media (e.g. Ravilious 2020; Clive Cookson 2020) and the research community (e.g. Araujo and Naimi 2020; Carleton et al. 2020; see a wider list in supplementary material 1) due to the possibility that summer weather might slow the spread of the virus. After going through all the steps of such an analysis, we reached the unexpected conclusion that the limitations of the available COVID-19 data are so severe that we would not be able to make any reliable statistical inference. This applies, for example, to the data provided by the John Hopkins University (Dong et al. 2020) and the data collated by Xu et al. (2020).

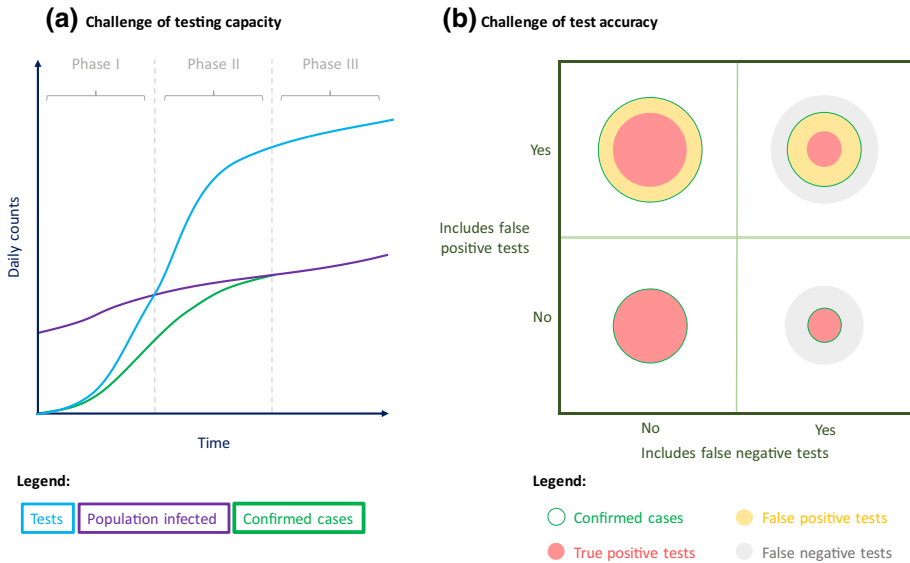
This is a concerning and very important finding considering that such data are being widely used to make crucial policy decisions on a wide range of topics. Since invalid causal inferences could be made with the publicly available COVID-19 data, and then enter policy-making discourse, there is an urgent need to raise awareness among the scientific community and decision makers regarding the limitations of the information at their disposal. The elements discussed in this paper are also likely to be applicable to other epidemiological datasets obtained with insufficient testing and monitoring, either during exceptional epidemics or seasonal outbreaks.

Several challenges could undermine any causal statistical analysis of the influence of a potential determinant, such as the weather, on the spread of COVID-19. To start, confounding variables are likely to pose a significant problem: many factors (e.g. changes in policy or social interactions) are simultaneously influencing how the disease spreads.

In addition, significant challenges come from the limitations of the COVID-19 case count data itself. Firstly, testing capacity has been a major issue in most countries. Before 1 March 2020, very few countries had sufficient testing capacity. By 30 April 2020, high-income countries had significantly increased their testing capacity, but testing remained critically infrequent in most low- and middle-income countries.<sup>55</sup> Figure 1, panel a, illustrates the effect that insufficient testing capacity has on the number of confirmed cases. It distinguishes between three phases of limited (I), intermediate (II) and widespread (III) testing. In Phases I and II, there is a risk that the number of confirmed cases depends more on the number of tests available than on the actual number of people who have COVID-19, questioning the validity of any analysis relying too heavily on these data.

Moreover, there have been numerous concerns regarding the accuracy of the COVID-19 tests performed so far (Ai et al. 2020; Apostolopoulos and Tzani 2020; Hu 2020; Hall et al. 2020). Figure 1, panel b, illustrates the effects of both false-negative and false-positive test results on the number of confirmed cases. False-negative results would imply that the number of confirmed COVID-19 cases is underestimated. False-positive results would imply that people who do not have COVID-19 are included in the number of confirmed COVID-19 cases. Concerns regarding test accuracy create an additional problem of measurement that might affect statistical analyses.

<sup>55</sup> Figures on testing are available in Our World In Data (accessed on May 1st, 2020): <https://ourworldindata.org/coronavirus>.



**Fig. 1** Difference between actual COVID-19 cases in population and reported confirmed COVID-19 cases. Confirmed COVID-19 cases (green) represent the number of people tested with a positive test result. They include false positive and exclude false negative tests. The circles of panel b represent the size of the populations with true-positive, false-negative or false-positive tests. Quantities in the y-axis of panel a, as well as the size of the circles in panel b, do not represent any true value or proportion. (Color figure online)

The two above-mentioned challenges are inherent in all current datasets of COVID-19 confirmed case count and mortality. In addition, specific datasets may have imperfect geographical or time coverage.

To look at the impact of the weather on the spread of COVID-19, we initially used a well-established approach, similar to the ones used previously to look at the impact of the weather on other diseases (e.g. Deschenes and Enrico 2009; Gasparrini et al. 2015) (see details in supplementary material 2). However, the fundamental measurement issues associated with the COVID-19 case count data cannot be corrected by statistical techniques, as we outline in the following.

The main problem is that the weather could be influencing the number of tests carried out and the segment of the population tested. For example, other respiratory diseases are often similar to COVID-19 in their symptoms (e.g. WHO 2020) and are more common during cold weather (e.g. Deschenes and Enrico 2009; Gasparrini et al. 2015), which could influence the number of tests performed on people displaying symptoms of respiratory infection. Therefore, even if the model correctly identified the impact of the weather on COVID-19 case counts, it cannot distinguish between the impact of the weather on the spread of the disease and its impact on testing. Table 1 provides a non-exhaustive list of elements that could undermine any analysis of the impact of the weather on the spread of COVID-19 using data on confirmed cases. The evidence suggests that the weather may correlate with the number of tests conducted and who gets tested. We have not been able to find any specific COVID-19-related evidence that the weather could impact test accuracy

**Table 1** Non-exhaustive list of reasons why weather conditions could affect the number of COVID-19 tests carried out and who gets tested

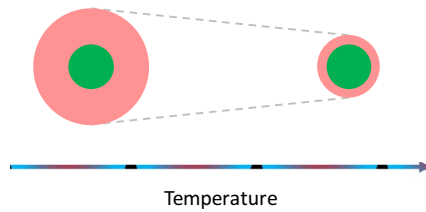
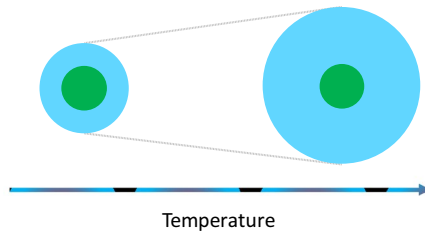
Potential reason	Potential implication
Unrelated respiratory diseases are weather sensitive (e.g. Deschenes and Enrico 2009; Gasparrini et al. 2015) and can be confused with COVID-19 (e.g. Ai et al. 2020; Chen et al. 2020)	More patients with symptoms of unrelated respiratory diseases could be tested during cold weather The prevalence of other weather-sensitive respiratory diseases might make false-positive results more likely, especially if only radiographic imaging is used, since it is possible to confuse these diseases for COVID-19 (e.g. Ai et al. 2020; Chen et al. 2020)
The incidence of other pathologies (e.g. cardiovascular diseases) is influenced by the weather (e.g. Deschenes and Enrico 2009; Gasparrini et al. 2015)	Hospital capacity and the workload of medical staff and testing structures are affected by weather conditions, with potential implications on the number of tests conducted At-risk individuals suffering from unrelated conditions are more likely to be tested for COVID-19, even if they only have mild symptoms for COVID-19
People may be more inclined to seek medical attention depending on the weather (e.g. Norris et al. 2014)	Due to weather conditions, people may or may not decide to seek medical attention, affecting the number of patients going to the hospital with COVID-19, and the workload of medical staff

(e.g. the weather affecting the nasopharyngeal or oropharyngeal swabs used in the PCR analysis), even though this could be possible.

Other points of concern include: the fact that there may be indirect effects of weather conditions on other factors that could have an impact on the spread of COVID-19 (such as social interactions or air pollution); the heterogeneity of impacts across populations and subgroups within a population; and the fact that some people may have travelled and therefore been infected in a different place from where the cases are reported.

We ran our model (as detailed in supplementary material 2) and provide results and robustness checks in supplementary material 3. The model would technically suggest a negative correlation (e.g. colder days would be associated with more confirmed COVID-19 cases, and hotter days with fewer cases). Yet, these results could be highly misleading since these estimates are likely to be substantially biased because of the aforementioned reasons.

Figure 2, panel a, provides an illustration of how we could have obtained a negative correlation even if temperature had no impact or a positive impact on the spread of COVID-19 in our sample. The total number of estimated cases is given by the size of the circles as a function of temperature (x-axis). The circles in green correspond to the effects we are interested in—those that explain the influence of temperature on the spread of COVID-19. If temperature has no effect on the spread of COVID-19, then the green circles should be the same size at low and high temperatures. The pink circles represent the possible effect of temperature on testing (as reported in Table 1) under the illustrative assumption that high temperatures reduce testing frequency. In this case, the overall result is a negative correlation between temperature and confirmed COVID-19 cases, even if temperature has no effect on the spread of the disease. In practice, we naturally do not know the direction of the bias caused by the effect of temperature on testing when using standard statistical methods. There is also no way for us to evaluate the contribution of each of these effects (green

**(a) Estimates are likely to be biased because the weather influences data collection****(b) Estimates could vary between samples**

**Effect of the weather on COVID-19 spread**

For example, SARS-CoV-2 is more infectious; the weather affects people's immune systems; People-to-people transmission is higher.

**Effect of the weather on tests**

For example, changes in the number of people with respiratory diseases other than COVID-19, affecting the number of tests performed.

**Effect of the weather in another sample**

For example, social interactions evolve; or samples are for different countries.

**Fig. 2** Effects potentially captured by our estimate. The size of the circles represents the estimated number of cases at different temperatures. These are examples that do not correspond to actual data. In these examples, we assume no correlation between temperature and the effects in green (see legend), a negative correlation with the effects in pink (example 1) and a positive correlation with those in blue. (Color figure online)

or pink) in our estimate. We arrive at the final size of the circles and cannot be sure if the association that we are interested in is either negative, null or positive.

Figure 2, panel b, focuses on the risk that effects could be different across different samples. The circles in blue capture other underlying factors that are influenced by temperature (such as acclimatization or the level of social interactions in the population), as well as other socioeconomic factors (such as the demographic characteristics of a population). These factors could be radically different in different regions but may also evolve over time (e.g. between winter and summer seasons).

There are strong reasons to be concerned with the scenario illustrated in Figure 2, panel b. In our sample, for example, we only have data from the start of the pandemic until end of April 2020; some countries (e.g. China) may be over-represented in the dataset; and the average daily temperature is relatively low at 10.5 °C. Furthermore, many countries have implemented a stringent containment policy during the period covered by the sample. Containment policies may have heightened (or lowered) the sensitivity of the spread of the disease to the weather because social interactions are limited. We are not able to observe how

the impact of the weather on COVID-19 might change at different gradients of social interaction. Finally, our estimate is based on small, observed changes in temperatures, and not on radical increases or reductions in temperatures. The spread of COVID-19 may respond differently to large variations in temperature, e.g. by 5 °C or 10 °C across seasons, making seasonal predictions even more unreliable.

Strong precautions need to be taken before using COVID-19 case count datasets for inference. The results of our model using existing COVID-19 data would seemingly imply a negative association between temperature and confirmed COVID-19 cases. Any projection of COVID-19 cases with such estimates could conclude that, during the upcoming months of June to September 2020, Southern Hemisphere countries would be exposed to higher risks of COVID-19 spread and Northern Hemisphere countries to lower risks.<sup>56</sup> These types of unsubstantiated results could be used as a misinformed justification for an early relaxation of effective social distancing measures in the Northern Hemisphere.

These findings have equally strong implications for statistical analyses focusing on other questions that rely on COVID-19 confirmed case count and/or mortality count data. Even though the exact nature of the effects may change, such studies are also at risk of capturing the effect that their parameters of interest have on tests and test results. For example, studies interested in the effect of containment policies may have to consider that these policies substantially affect testing because they change the awareness of the disease in the population, political demands for more testing or the risk of contracting other respiratory diseases. Other studies may also produce estimates that are very specific to the current circumstances in the development of the pandemic and are, therefore, not suitable to use for forecasts of what could happen in the coming months.

In the medium term, more reliable data need to be gathered, for example through experimental studies that randomly test a sample of the population for COVID-19. In the short term, we are in a situation of fundamental uncertainty about how different factors affect or are affected by the widespread societal changes we see with the COVID-19 pandemic. Therefore, scientists, policy makers, journalists and the general public need to be very cautious when discussing how the spread of COVID-19 correlates with the weather or any other factor.

In the long term, this paper suggests that more attention should be given to how epidemiological data is recorded and used during exceptional epidemics and seasonal outbreaks, since insufficient testing and monitoring can undermine essential statistical analyses. This article calls for the complementary use of different methods for data collection, such as random testing in samples of the population.

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<sup>56</sup> We performed such a projection to confirm this point (see supplementary material 4).

**Authors contributions** Cohen is the first author. He had the original idea, wrote most of the paper and the code to produce the econometric analysis. He also coordinated the team. Jani ensured the material was consistent with the epidemiological evidence. Li produced the required climate data for the statistical analysis. Lu helped on literature review, on coding the econometric analysis and on producing the tables. Schwarz helped on data coding and matching and created the projections. All authors contributed to the text.

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**Data and materials availability** All data and software are publicly available at <https://github.com/moritzpschwarz/COVID-19-weather-Oxford>.

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## Supplementary Materials

1. References from the emerging literature on the spread of COVID-19
  2. Data and methods to correlate weather conditions to confirmed COVID-19 cases
  3. Main results and robustness checks
  4. Information on projections
- Table A1–A6  
Fig A1–A2