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COVID-19 and Climate Change: A Tale of Two Global Problems

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Abstract: In this paper, we examine the similarities and the differences between two global problems, the coronavirus pandemic and climate change, and the extent to which the experience with the COVID-19 pandemic can be of use for tackling climate change. We show that both problems share the same microeconomic foundations, involving an overprovision of a global public bad. In addition, they entail externalities whose correction comes at very high economic and social costs. We leverage on a well-established problem such as climate change that has been studied for several years now, to highlight the common traits with the COVID-19 pandemic, but also important differences. The COVID-19 crisis is itself a reality check for climate policy, international governance and prevention in general. Indeed, the COVID-19 pandemic is a mock laboratory of climate change, where the time scale of unfolding events is reduced from decades to days. While the former is often measured in days, weeks, months, years, the latter is measured in years, decades, and centuries.

Keywords: adaptation; climate change; coronavirus; COVID-19; global public goods; mitigation; technological innovation; COVID-19

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1. Introduction

In this paper, we examine the similarities and the differences between two global problems—the coronavirus pandemic (hereafter COVID-19) and climate change—and the extent to which the experience with COVID-19 can be of use for tackling climate change. COVID-19 is the name given to the disease associated with the virus SARS-CoV-2 (Severe Acute Respiratory Syndrome-Coronavirus-2), a new strain of coronavirus that has not previously been identified in humans. As terrifying and destructive as the COVID-19 crisis is, it is just a preview of the increasingly severe disruptions that climate change will bring. Indeed, the COVID-19 crisis is itself a reality check for climate policy, international governance and prevention in general; the COVID-19 pandemic is a mock laboratory of climate change, where the time scale of unfolding events is reduced from decades to days. While the former is often measured in days, weeks, months, years, the latter is measured in years, decades, and centuries.

Following [1], in this paper we use the conceptual toolkit of environmental economists to reflect on some issues related to the COVID-19 pandemic. We aim to provide a reading of the emergence of the pandemic using reasoning and relying on existing environmental and climate change economic research. Our contribution is to focus on COVID-19's microeconomic foundations, draw analogies from climate change to structure the problem and offer ways to instrument solutions. Our aim is to try to structure a complex and overwhelming problem, such as a COVID-19, by drawing elements from a complex and overarching, yet fairly well-studied problem, such as climate change.

Based on the argument that climate change and COVID-19 share a similar structure, that their economics are conceptually fairly similar, and that policy responses follow the same format, some insights derived from the COVID-19 experience may be relevant for climate change policy. To derive these lessons, we adopt a bottom-up approach of individual incentives and behavior, rather than a top-down sectoral (transportation, energy, retail, etc.) approach. The main messages from our analysis are (1) during the lockdown, emissions fell in the most expensive way, which is by halting the economy. After the pandemic, it would be difficult to oppose cheaper tools to achieve climate goals, such as carbon pricing. Even these reductions would not be enough to meet climate policy targets. (2) A change of behavior is possible, driven by new social norms that can alter the way we work, where we live and how we spend our leisure time. This reorganization can affect carbon emissions trends. Related to that, (3) in a post-COVID-19 world, proximity or contact-related considerations are likely to determine the organization of the economy. In a new low-contact economy, the prime objective is to reduce the risk of infection. Therefore, activities that reduce the physical interaction or are otherwise considered safe will flourish. Whether or not these activities would result also in a reduction of GHG emissions is likely not going to be a primary concern. The energy footprint of each economic activity is independent of how risky it is in terms of COVID-19 infections. However, this rebalancing of activities would indirectly determine a different pattern of energy consumption, and in that way affect the overall energy mix and emissions.

We derive these lessons with the limited information that we have on COVID-19 at the moment of writing, but that is compensated with the vast amount of research available on climate change. As definitive lessons may have to wait until we know how the pandemic ends, we decided to focus on general lessons and implications which are more likely to survive the test of time. We therefore sought to strike a right balance between completeness, clarity, complexity, and limited data.

The paper is organized as follows. In Section 2 we begin to describe the microeconomic structure of the COVID-19 pandemic, using climate change as analogy. Framing the issue in this way leads to policy responses that for both problems entail mitigation as well as adaptation, and to the fact that international collaboration is needed. We discuss these policy aspects in Section 3. In Section 4, we discuss the lessons that can be drawn from the experience with COVID-19 that can be useful for tackling climate change. In Section 5, we acknowledge some limits of our conclusions by discussing the differences that also exist between COVID-19 and climate change, and discuss the extent to which our insights might change because of these differences. Section 6 concludes the paper.

2. Selected Literature Review

Most of the economic analysis of the COVID-19 pandemic has been focused on the immediate impacts, costs and sustainability of national health systems, on the one hand, and on the socio-economic consequences of the pandemic and its immediate aftermath. An increasing debate and a rapidly growing section of the literature are looking at macroeconomic consequences of the lockdown, its impacts on employment, the organization of production and on several industries, including transport and tourism [2–6].

In addition to the above aspects, a few researchers have recently come to place the COVID-19 pandemic next to the environment. Specifically, a significant reduction in local pollution has been noted since the COVID-19 outbreak, and this has led researchers to ask if this link is more than a correlation, but the former causes—or helps cause—the latter. At the time of writing, there are still few scientific papers, but the literature in this area is growing rapidly [7–12].

The link between COVID-19 and climate change has also been analyzed, albeit in different ways. Some have questioned the role of climate change as one probable cause of the appearance of the virus in its transition from animals to humans [13]. It is well known that rising temperatures can create favorable conditions for the spread of air-, water-, and vector-borne diseases, such as malaria and dengue fever, while disappearing habitats may force various animal species to migrate, increasing the chances of spillover pathogens between them [14–16]. Conversely, the same factors that mitigate environmental risks—reducing the demands we place on nature by optimizing consumption, shortening and localizing supply chains, substituting animal proteins with plant proteins, decreasing pollution—are likely to help mitigate the risk of pandemics.

Others have asked whether the COVID-19 outbreak and the associated lockdown of economic activities will lead to a long-lasting reduction of carbon emissions [17–19]. While a consistent reduction is expected this year and perhaps the next, the more relevant issue is to what extent the trend will continue, especially with respect to the type of support policies every government around the world is introducing and the changes in the organization of production as we have been knowing it. For example, according to [18] certain temporary adjustments, such as teleworking and increased reliance on digital channels, may endure long after the lockdowns have ended, thus reducing transportation demand and emissions. Others argue that COVID-19 is a historical opportunity to reset the path of economic development and reboot it on a low-carbon alternative, for instance taking advantage of low interest rates to boost sustainable investment projects [20–24]. However, it is also noted that this goal may not be seen by governments and citizens alike as an immediate priority amid the pressing needs of the recovery, let alone that super-low oil prices are not likely to help the transition to carbon-free energy sources. As an example, Canada's Prime Minister, Justin Trudeau, is reported to be abandoning his climate policies under increasing pressure, and has already announced a plan to support the oil industry. We do not follow any of these threads here. Instead, we offer a conceptual roadmap of the pandemic that relies on the basic structure of the climate change problem.

3. Method: Structuring COVID-19 through the Lenses of Climate Change

In this section, we argue that the analogy between climate change and COVID-19 is useful to structure problems and to derive lessons. The main reason for putting climate change next to COVID-19 is because the two problems are, from an economic standpoint, conceptually similar, as both can be characterized as global public bads and as negative externalities—climate change is a global externality and so is COVID-19, as contagion is a transboundary phenomenon. As a matter of fact, COVID-19 is akin a transboundary pollution problem, originating in one country but able to cause damage in another country's environment (population), by crossing borders through pathways like water or air (people's movements). Pollution can be carried away from a heavy emitter and deposit onto a nation whose emissions are relatively low. Due to the fact that "all things connect", the heavy pollution that is evident in the developed world also becomes evident in remote areas.

3.1. They are Both Global Problems

Climate change is a problem for the entire planet. It is global as it arises from greenhouse gas emissions, which are generated in all parts of the globe. Likewise, its impacts are felt in all world regions. COVID-19 is, in principle, a transboundary problem, because it is borne in one (or more) region but it can rapidly expand to the whole planet, moving from an epidemic to a pandemic. Being currently a pandemic, COVID-19 is now a global problem like climate change. In addition, the two problems are global in a different way. Climate alterations and global warming are induced by increasing atmospheric concentrations of Greenhouse Gases (GHGs), regardless of the geographical location of the emissions. It follows that the impact of climate change on a specific country is to an extent independent of its own emissions, thereby creating an incentive to free ride on mitigation. Not so in the case of COVID-19, where the impact is transboundary, more like NO_x and SO_2 emissions, but one affected country cannot benefit from coping policies undertaken in another country, if not to a limited extent.

Another concept that can be borrowed from Environmental Economics and applied to COVID-19 and climate change is the difference between point-source and nonpoint-source pollution. Point-source pollution is easy to identify as it comes from a well-identified emitter or place. Nonpoint-source pollution is harder to identify and harder to address. It is pollution that comes from many places, all at once, with pollutants released in a wide area.

3.2. They Are Both Public Bads

In the presence of a global pandemic, public (non) health has the characteristics of a public good (bad): it is not excludable—it is highly contagious—and non-rival in consumption as getting the virus does not limit or prevent other people from getting the virus as well. Likewise, climate mitigation does not exclude anyone from benefitting, while its absence does not exclude people or countries from suffering the adverse consequences, such as extreme weather. Of course, "consuming" extreme weather does not prevent others from suffering from it as well.

We know that a problem with pure public goods is the lack of incentives for the private sector to provide it and its under-provision relative to the socially optimal level even with public intervention. When the public good/bad is global or transboundary, international cooperation is necessary, which raises the problem of free riding.

While the incentive to free ride on other countries' costly climate mitigation is obvious, free riding between countries is less evident for COVID-19. It was noted above that the impact of climate change on a specific country is to an extent independent of its own emissions—as it is evident for poor developing countries or small island states—and this creates an incentive to free ride on mitigation. In the case of COVID-19, the extent to which one affected country can benefit from coping policies undertaken in another country seems limited. One exception is the (free) learning from other countries' experience in dealing with a new disease. Yet, in a globalized world where people are free to move, the impact of COVID-19 on a country does not entirely depend on its own actions to prevent it.

In the case of climate change, the incentives to free ride produces a competitive equilibrium that is suboptimal, as the level of emission by individual countries, individuals and firms is higher than the level socially optimal. Something similar, "within country", occurs in the case of COVID-19. The private incentives to stay home and reduce social interaction produce a sub-optimal decision for individuals, that stay home less than what it would be socially optimal. In both cases the "tragedy of the commons" applies, and individual actions can run counter to the collective good and deplete a precious, common resource.

3.3. They Are Both Negative Externalities

Both climate change and the COVID-19 pandemic are stock externalities with negative consequences for agents' wellbeing. A stock externality does not exhaust its negative impact within a single period of time, but it spreads it across time and generations.

In the case of climate change, GHGs stay in the atmosphere for long periods—carbon dioxide for 50 to 200 years, fluorinated gases for more than thousand years—so that adverse impacts affect both current and future generations [25]. In COVID-19, the stocks of infected people increase the chances of others to be infected (infection externality), increase the likelihood of health systems to collapse, which imposes external effects on the ability of new sick people to get treatment (congestion externality). However, reaching a threshold stock of infected people leads to herd immunization.

The characteristic of being a stock externality leads to exponential problems. A stock is formed when either the speed of inflows is faster than the discharge outflows, or if there are no outflows at all. This applies when unabated GHG emission flows are larger than absorption by natural sinks—land and oceans—or artificial sinks such as carbon capture and storage. In the case of COVID-19, it is the speed of contagion that is leading the stock accumulation, while for climate change is the insufficient discharge.

The scale of both problems is huge, with potentially catastrophic consequences and high death tolls. Three months after China reported the first COVID-19 victim, the world accumulated more than 2.5 million positive cases and more than 175,000 deaths, with almost every country in the world declaring both contagions and victims, as it is reported by the Johns Hopkins COVID-19 dashboard (https://coronavirus.jhu.edu/map.html). Note that the worldwide lack of capacity for testing the virus and the different methodologies accounting for the number of deaths have created a large consensus about both the number of positive cases and victims been largely underreported.

3.4. They Both Involve Informational Asymmetries

Another market failure is worth mentioning. In COVID-19, there are information asymmetries concerning the knowledge of the disease within populations and across countries. Some governments—Brazil is a case in point—decided to face moral hazards taking unusual risks by choosing not to act, or not to act swiftly, in order to avoid the loss of short-term, short-lived electoral and economic gains [26]. This behavior is also apparent when it comes to the consequences of climate change and the need to take immediate action.

Adverse selection is also an issue. In the case of climate change, there is the risk/likelihood that more sustainable practices entailing more costs are not undertaken, as information on potential benefits is not available to potentially benefitting agents. For COVID-19, only those with evident or strong symptoms are treated or, alternatively, only those with health insurance get treatment.

4. Analysis: Policy Responses

In this section, we discuss that the structure of policy responses to climate change and to COVID-19 noting that both appear to have the same conceptual structure. Because both problems are stock externalities, responses entail both mitigation and adaptation. While the latter is likely to be of more relevance for climate change given the much longer time scale, all broad policy responses are shaped by the available time frame and by the degree of international cooperation that results in more coordinated policy implementation [27].

The two main responses, mitigation and adaptation, are implemented with the best current technologies under gradual technological change. A game changer in the policy responses would however be the irruption of new technologies, even if there remain social and economic barriers and obstacles that prevent most of the times a first best solution.

4.1. Mitigation

The objective of mitigation is to delay and reduce unwanted effects. As a stock externality, the immediate focus of mitigation is on diminishing rates of emissions/infections to stay below the limit of absorption capacity of emission in the atmosphere/of medical equipment and structures so as to reduce the outcome of worst case scenarios—beyond 2 °C/below the limit of hospital beds in intensive and pre-intensive care.

As more than 70% of GHG emissions are energy related, the goal of mitigation is therefore that of favoring the reduction of energy consumption and the transition to carbon-free energy sources. The policy instruments for that purpose include carbon taxation and cap-and-trade schemes. In addition, subsidies or mandates aimed to energy efficiency improvements lead to produce the same with less energy used. As shown in Table 1, the policy instruments are either market-based or command and control measures. As GHG emissions are largely a byproduct of the use of fossil fuel energy sources, which are large input of the economic activity, curbing emissions will reduce the scale of economic growth, if we assume that the composition and the current technologies remain unchanged, which is mostly the case in the short term.

In COVID-19, mitigation entails reducing the rate of infection. The tools available to do this are increased personal hygiene, adoption of personal protective equipment (PPE), home confinement and reduction of social interaction. Households mitigate the spread of the disease by reducing consumption, reducing hours worked, and working from home. Working from home is subject to learning-by-doing and the capacity of the health care system is limited [28]. While physical distancing measures can safeguard public health, they also can profoundly impact the economy. A social planner would worry about two externalities, an infection externality and a healthcare congestion externality, but coping with them drives the economy to a halt and leads to a recession [6]. Indeed, as basic

Environmental Economics suggests, the socially optimal level of production and associated pollution is found when the marginal net benefit of production is equal to the marginal cost of pollution damage. The higher the damage risk of a certain pollutant—lead in petrol as opposed to biochemical oxygen dissolved effluent—the higher the marginal cost to society the lower the socially optimal level of production/pollution.

Table 1. Mitigation policies.

Policies	Climate Change	COVID-19
Command and Control	Quantitative limits to CO_2 emissions (quotas) Energy efficiency mandates Requirement of adoption of particular technologies (or dismissal of some technologies)	Home confinement Mandatory shutdown
Market based	Carbon taxes Emission trading markets Subsidies to carbon-free technologies and to energy efficiency improvements	Voluntary remote working Social distance
Technology	Batteries, CCUS, Hydrogen, Thermal radiation management	Vaccines, specific drugs, new treatments

Delaying action comes at a cost in both cases. In the case of COVID-19 where the risk to human life is huge, the economy has nearly ground to a halt. Ref. [29] show for a sample of eight countries that delaying a lockdown for one week would have costs more than half a million lives. The implicit costs governments were prepared to pay to protect their citizens measured as economic activity forgone to save lives ranges from USD 100,000 (e.g., the UK, US and Italy) to in excess of USD 1million (e.g., Denmark, Germany, New Zealand and Korea).

In the field of climate change, more mitigation implies a tradeoff between reduced current production and welfare today and increased production and higher welfare in the future, so that the optimal policy will make the discounted marginal net social benefit of reducing one unit of CO_2 equal across time periods. As both the stream of benefits and damages occur at different moments of time, the discount rate plays a crucial role. In addition, give the time scale of the phenomenon and its complexity, uncertainty is pervasive and the risk of catastrophic outcomes suggests the adoption of the precautionary principle.

In the longer run, climate change can be mitigated with the development, adoption and diffusion of new technologies, with appropriate demographic policies, with changes in the compositional structure of consumption and production, and with changes in attitudes, lifestyles, preferences, and habits. In the case of COVID-19, where the longer run might mean a one-/two-year time frame, the carbon-free technologies would be new medication and drugs together with procedures and practices that would successfully treat all people infected (more like incremental innovation) and, even more, a vaccine that would shield all individuals from the disease (more like disruptive innovation).

4.2. Adaptation

The goal of adaptation is to alleviate the inevitable negative impacts on human beings, their activities, and the planet. Adaptation measures are pervasive when it comes to climate change, but perhaps sustainable agriculture, coastal ecosystems ("blue carbon"), ecosystem restoration, prevention of ecosystem degradation and urban and infrastructure system transitions (including land use planning, transport systems, and improved infrastructure for delivering and using power) are exemplary of the investment needs in climate-resilient infrastructure. In climate change, adaptation is not only necessary, but also largely case specific and mostly pertains to developing countries where negative impacts hit the hardest.

For COVID-19, adaptation measures will be needed even more in those countries where the health system is more precarious or where universal health insurance is lacking. Investment in hospitals, medical equipment and health infrastructures as well as in facilities that allow social distance are adaptation measures that apply to the case of COVID-19. In COVID-19, adaptation can take many forms. It may consist, for example, of developing a medicine that reduces the symptoms or the length of illness, of investing in advance in the reserve margin of ventilators or hospital beds. Or, again, in parallel to vaccine development (R&D), it may entail setting up different manufacturing facilities where the most promising vaccine will be produced, so as to reduce the lead time of production.

In addition to these considerations, inasmuch as climate change requires intervention and investment in prevention, restoration, and resilience, COVID-19 requires active fiscal and monetary policies to contain and reduce as much as possible the consequences on people's incomes and jobs.

For both phenomena, adaptation cannot do without mitigation. In the case of the former, the underlying assumption is that some of these investments might not be needed, but the precautionary principle applies. It is possible that, given the uncertainty, under successful mitigation action some of those public investments in adaptation would be sunk, with the need to deal with a fiscal problem.

Finally, addressing COVID-19 pandemic and climate risk requires the same fundamental shift, from optimizing largely for the shorter-term performance of systems to ensuring equally their longer-term resilience.

4.3. Technological Innovation

While there are several examples of new technologies that can help mitigate a changing climate, by either reducing GHG emissions or interrupting the complex link between GHG concentrations and climate alterations—including, but not exclusively, increasing temperatures—in the case of COVID-19 the technological breakthrough has one name: vaccine.

The distinction between basic and applied research is well understood. While basic research is one that adds further knowledge to the actual knowledge, applied research is knowledge that is put to practical use and is beneficial to solve practical problems. Technological innovation in climate change and in COVID-19 involves both basic and applied research. Due to the public good nature of the former relative to the latter, under provision relative to the socially optimal level is a key feature, together with the fact that government or public research institutions typically are called for in its provision. Public financing along with private financing (provided legal mechanisms to protect the innovation are in place for private actors) is necessary.

Given the compressed time frame of COVID-19 and the perception of the immediate high risk involved, significant financial sources and public and private research institutions are activated to hastily find and produce a solution. In the case of climate change, research activity is admittedly facing a much more complex problem, one whose consequences are (mistakenly) perceived by policy makers and the general public as less urgent, and is more widespread and undertaken on a quite different financial, geographical, and temporal scale.

This last observation relates to the issue of international collaboration. In the case of COVID-19, collaboration and competition among international and national research entities increases the likelihood of coming up with a valid vaccine in the shortest time possible. Knowledge sharing and free patenting are considered as moral imperatives. In the case of climate change, while international networks of research institutions, laboratories and universities are characterized by collaborative initiatives, knowledge sharing and spillovers in basic research, competition is more a feature for private actors and insufficient financing a feature of many governments.

4.4. International Cooperation

Due to the global public's good nature, cooperation between countries is required for an efficient solution to both problems. Cooperation requires individual incentives to be aligned, positive net benefits, and transaction costs that are not too high. According to [30] classification of cooperation for the provision of global public goods, “supply” of climate change mitigation falls into the category of “aggregated effort” global public good: reducing the world’s GHG emissions depends on the aggregate effort of all countries and a single country cannot stabilize atmospheric concentrations of greenhouse gases all by itself, certainly not by reducing its emissions unilaterally. “Supply” of COVID-19 eradication is a “weakest link” global public good because it requires universal cooperation: no country would really be safe if the virus is still active somewhere in the world [31]. In the first case, cooperation is needed to determine individual efforts to achieve an overall outcome, while for the latter cooperation is needed to establish minimum standards.

In the case of climate change, negotiation is an ongoing event and pertains to the design of a climate architecture that includes an international agreement and its implementation inclusive of monitoring, verification, reporting and compliance. The climate agreement needs to be designed in a careful way for it to be effective, efficient and equitable. Specifically, the international agreement should be such that (i) each participant is better off with than without the agreement, (ii) there is no incentive to free ride, so that each participant is better off inside the agreement than outside the agreement with other parties committed to the agreement, (iii) transfers from winners to losers or to potential free riders (altering initial payoffs) or incentives to increase coalition stability (to enlarge the gains from cooperation) are envisaged. Free riding largely explains the slow progress of the negotiation, and the Prisoner Dilemma is the outcome.

The experience with COVID-19 shows that international cooperation easily breaks down during a crisis [32]. In the case of the COVID-19 pandemic, timing is a critical issue. Being transboundary, cooperation among countries is critical at the outbreak of the infection, which spreads quickly across space. There is little time for negotiation and the incentive to act for any one country in view of the common good depends on that country’s belief that others will also act. There cannot be exceptions, because the failure of one country to act threatens all the others.

Coordination is crucial and the current experience suggests that it has failed with countries acting on their own. The current crisis might be a critical conjuncture for governments and institutions. It is not at all clear what will be the international scene emerging after the COVID-19 pandemic. It might be either a more nationalistic and anti-globalization approach or a multilateralism spirit leading to a greater international cooperation and coordination. The final result being one or another will have important consequences to tackle the challenge of climate change. Reluctance to initially admit the existence of the epidemic, introduction of travel restrictions and of trade restrictions, borders closing, competition not collaboration of medical supplies, not to speak of alleged attempts to strike exclusive vaccine deals in foreign countries are all cases of prevalence of self-interest in the COVID-19 pandemic and of a Prisoner Dilemma-type situation. The absence of coordination at the time to close borders is an example. Currently, every country is individually looking for a vaccine, but in an uncoordinated way, with competition prevailing over coordination. Nevertheless, once the vaccine is developed, it may be the case, and hopefully so, that the formula is shared among countries so that its production and diffusion can reach all the population. Similarly, given the strong economic ties between countries, there can be some coordination on the economic measures to cope with the harsh consequences of the pandemic. The current experience within the EU is showing how difficult that goal can be reached.

4.5. Barriers and Obstacles

Social barriers and obstacles make more difficult the implementation of policy responses. In the case of COVID-19, we may question whether the main mitigation tactic, social distancing, is inherently self-defeating. Social fabric (social capital) diminishes with less interactions, but you need social fabric to stay away from crowds, as the motivation to do so is, to some extent, altruistic. You do this because you understand this action is not only to keep you safe, but to keep others safe.

COVID-19’s obstacles are also represented by geo-political incentives to understate the initial size of the outbreak, to a slow or delayed disclosure of the problem by the country where the epidemic sets out. Once the disease becomes diffuse, obstacles and barriers to an efficient solution are represented by inadequate and imperfect information about the characteristics and the consequences of the infection, as well as non-compliant behavior be individuals [33].

Climate change threat is intangible and diffuse, and it can be obscured by natural variability (unlike, for instance, urban air pollution). In addition, the “carbon timescale” is poorly matched to the political process. There are and will be inevitable distractions, like a few years of cooling, economic downturns, unforeseen events (like tsunamis and virus outbreaks). Energy is at the heart of economic activity. There can be diverging expert opinions and, above all, disinformation (e.g., President Donald Trump on meteorology vs climatology).

5. Discussion: Lessons from COVID-19 for Climate Change

COVID-19 is a new phenomenon. Experts expect the virus to remain among us for at least two years. As a historical event in the making, there are still huge uncertainties how this crisis will unfold and eventually end and what will be its long-lasting consequences. It would be daunting to pretend to put forward definitive lessons.

However, COVID-19 is also a super-fast-paced event. The situation changes continuously; developments and findings are made almost every single day; a lot of information has accumulated since the start of the crisis. It would, therefore, seem that speed can serve as a test for climate change, whose events unfold in a very slow fashion. In addition, the perception of the costs of inaction and of action is more apparent for COVID-19 than for climate change—although, in theory, climate change would be even more devastating.

What would governments, firms and individuals have done in November 2019, a month before the eruption of the coronavirus epidemic in preparation of what was going to come, is a question that bears analogy with what countries should do in 2020 in view of something that might happen in 30 to 50 years’ time. It is telling as well as paradoxical that the COVID-19 pandemic caught the world off guard, while the world is responding very slowly to the threat of climate change. Adopting an inductive approach, we can attempt to draw some lessons that we obtain from observation of the reality. Like a fable, lessons of COVID-19 for climate change show a moral, the benefits of following the moral and the consequences of not following it.

5.1. Emissions Reductions at the Most Expensive Cost

Perhaps the main reason why countries, firms and people have been so far reluctant in engaging in a serious and strong action to tackle climate change is due to its presumed high economic cost. It could be that waiting until the last minute would force countries to reduce emissions by completely halting economic activity. By virtue of its speed of diffusion, the COVID-19 pandemic is showing the world what shutting down the economy to halt contagion means.

The cost of halting the economy, that as a side effect has produced this emissions reduction has been unprecedented. Countries like Mexico, Spain or the UK have experience drops in GDP in double digits. The argument in favor of increasing carbon prices have in the past been depicted as an intolerable burden to society. After COVID-19, it will be difficult to discard economic arguments against climate policy in this way, as the economic costs of limiting climate change to below two degrees are projected to be orders or magnitude lower than those of COVID-19 [34].

Emissions reductions from the lockdowns appear to be rather small. [35] estimated that daily global CO_2 emissions decreased by −17% by early April 2020 compared with the mean 2019 levels, while the impact on 2020 annual emissions depends on the duration of the confinement, with a low estimate of −4% if pre-pandemic conditions return by mid-June, which we observed in many countries. [19] estimates that existing climate policy measures will likely reduce emissions more than 40% by 2030 in the wake of the pandemic. However, these reductions will not be enough to meet the Paris agreement. This suggests a need for a much deeper social change coupled with a green transformation that decouples economic activity and carbon emissions [34]. We still lack a clear understanding of how such an economy could look like but we posit one possibility in the Section 5.3.

There is another aspect that plays out, which it has to do with uncertainty and perception. Aside from genuine uncertainty due to still-imperfect scientific knowledge, the long time frame of climate change favors the divergence between perceived and real social and economic costs of future impacts and an undervaluation of the damages, and thus of the benefits of action. Even the more immediate economic cost of emission reduction pathways may be overstated, as suggested by supporters of sustainable development and "green economy" strategies.

Not so with COVID-19. Without long time scales, there is little room for a perception different from reality and the source of uncertainty seems to be largely of scientific nature. Even the economic consequences of the pandemic seem to be largely apparent to all.

5.2. A Change in Behavior Is Possible

Many experts have been stressing that the solution to the climate change problem requires a change in behavior, habits, lifestyles when it comes to consumption, etc. A second lesson that can be drawn from another observation seems to be that a sudden and sharp change in behavior (and mindset) is possible, driven by new social norms like wearing a mask or keeping social distance. The COVID-19 pandemic may have long lasting consequences in the way we work, where we live, and how we spend our leisure time [36,37].

The coronavirus crisis is showing that a change in behavior in consumption, transportation, production, etc., is possible with current technologies when the situation forces people to do so. There are far-reaching implications of this. For example, working from distance can be efficient. Use of office space under normal circumstances now seems to be highly inefficient in the sense that the same can be achieved without commuting time, congestion, transport emissions, etc. Travel is not a necessary input for the production function of the way we conduct business. Face-to-face businesses will suffer, in favor of remote, distanced services. If some or most of these temporary adjustments endure after the lockdowns have ended, they will have impacts on domestic electricity loads, oil demand, and emissions.

Yet, it seems that the change in behavior has been enforced largely by the seriousness and credibility of the mortal threat. As to climate change, this brings back the timing issue and perception vs reality discussed in the previous section.

5.3. Re-Organizing the Economy: Will the Low-Contact Economy Also Be a Low-Carbon Economy?

A key implication of COVID-19 for climate change is how economies will be organized as a result of the pandemic. The question is whether this low-contact economy will be a low-carbon economy as well, where energy has been at the heart of economic activity. In a post COVID-19 world, it will be the basic human interaction which would determine the organization of this new economy.

While some have argued that this is a once in a lifetime opportunity to reboot economies with a low-carbon mindset, that cannot be taken for granted [38]. In the recovery that will follow, economies will likely be re-organized first in order to reduce contagions. Only if a low-carbon organization is compatible with that goal will have a low-contact and -carbon economy.

A low-carbon economy will favor those activities whose production include a clean environmental advantage in terms of reduced emissions. In the aftermath of the main COVID-19 crisis there is a change in demand preferences. The most important attribute in economic exchange would also be cleanliness, but in hygienic meaning. The chances are that, instead of preferring activities with no emissions, we will prefer activities with no contagions.

This problem can be illustrated with the "packaging paradox". Prior to COVID-19 crisis, one of the main concerns with that packaging was (i) reducing waste, and (ii) using preferably recyclable material. With the emergence of COVID-19, packaging is something that might protect people and allow them to stay healthy. The main desirable attribute of packaging would be to have a surface that is easy to clean or a material that is inhospitable to viruses and germs. Design of packages where there is a single point to hold them, where many hands touch them, will no longer work. It may be that the future of packaging would, therefore, include personal disposable handlers. The extent to which this new desirable attribute come from recycling sources is not guaranteed. Actually, the effects for the environment of the disposal of PPE (gloves, masks, etc.) are already been seen.

6. Caveats: Differences between Climate Change and COVID-19

The underlying thread of this paper was the similar conceptual microeconomic structure of climate change and COVID-19 problems. Of course, the match between COVID-19 and climate change is not at all perfect. There are important differences that need be acknowledged.

One key difference is the cost of inaction. If left to its own, the cost of the COVID-19 pandemic is high mortality, which will have profound social, family and personal implications. Of course, consideration should be given to the opportunity costs of those deaths, as we miss what they would have achieved in the victims' lifetime [39]. If we accept this fate, economies would not need to stop. The grounds for action in COVID-19 is therefore a moral one, i.e. we cannot accept idle action while people die. The cost of inaction for climate change, on the other hand, could be argued to be much higher, entailing the potential destruction of the planet or of its habitats. Climate change could thus threaten our very existence as human beings.

A second difference is about irreversibility. There can be thresholds and tipping points which may make climate change an irreversible problem. We cannot re-engineer the climate back to where it was. The COVID-19 pandemic entails some reversibility with some temporal costs and some other irreversible costs. While economic damages can be reversed with time, irreversible losses and deaths cannot.

A third difference is uncertainty and perception. Climate change is uncertain in its timing and extent. The climate threat is intangible and diffuse and it can be obscured by natural variability. The risks from climate change are gradual, cumulative, unevenly distributed across space and over time. Those risks require action now in exchange of a future reward that has in the past appeared too uncertain and too small given the implicit "discount rate." This is what former Bank of England Governor Mark Carney has called the "tragedy of the horizon" (see, for instance https://www.mainstreamingclimate.org/publication/breaking-the-tragedy-of-the-horizon-climate-change-and-financial-stability/).

The Giddens Paradox for climate change establishes that, no matter how great the dangers posed by climate change, their lack of immediate visibility in the everyday world means that people will not act to deal with them; by the time the dangers are immediately visible, it will be too late for any action on the part of the people to be effective [40]. The point of the paradox is that issues which are invisible and intangible at the level of the immediate sense may well be massive in their effects and impacts.

The consequences of COVID-19, in contrast, are tangible and near. While still an uncertain event and perception is imprecise, the time frame makes it very palpable. A global public health crisis presents imminent and directly discernable dangers, which we have been conditioned to respond to for our survival. The costs of mitigation and size/value of damages increase with delayed action and are more visible in the COVID-19 pandemic.

A fourth difference is that the priority given to COVID-19 and to climate change in the political process also differ. This has to do with the high short-term costs of COVID-19 and the, allegedly, relatively low short-term costs of climate change. Time scales are poorly matched to the political process. This is not the case with COVID-19 which, as an example, could turn out to be a game changer in the U.S. presidential election later this year.

Is the COVID-19 crisis different from climate change because impacts of the latter are too far away? Climate change is a long-term phenomenon. Assessing impacts on environmental and socio-economic systems requires a long-run framework that integrates intergenerational altruism. This brings about the problem of choosing the social discount rate, which may dramatically alter any cost–benefit analysis, as there is the need to discount very distant societal benefits to the present. Rather than an intergenerational discount rate, with COVID-19 the issue is intragenerational. The weights of different groups in a social welfare function will lead to different optimal policies, as the trade-off between health and the economy, is not the same for young and old generations.

7. Conclusions

This paper has focused on COVID-19's microeconomic foundations with the aim to try to structure a complex and overwhelming problem by drawing elements from a complex and overarching, yet fairly well-studied problem, such as climate change. To do this, we have made use of the economics toolkit to try to delimit the problem in a way that we could tell a coherent story of what is going on both fronts. We have highlighted the analogies of the two global problems, but also the differences.

The COVID-19 crisis offers unprecedented insights into how a global crisis may be managed, such as climate change. We adventure the following lessons:

- Lockdowns triggered emissions reductions, but these were achieved in an undesirable way, halting entire economies. More efficient ways to achieve emissions reductions are available. It is difficult to argue now against a carbon pricing, for instance.
- A bottom-up change of behavior and in social norms is possible in response to a crisis. COVID-19 could have long lasting changes in the way we work, where we live, and how we spend our leisure time. This rebalancing of activities would indirectly determine a different pattern of energy consumption, and in that way affect the overall energy mix, and therefore on emissions.
- Global problems require multiple forms of international cooperation and competition. However, international solidarity weakens in times of crisis.
- Lack of global coordination delays actions and this is very costly.
- Prevention is the best course of action. It is also a public good and, therefore, will be undersupplied.
- Policy design must go hand to hand with science, but science advances faster than the policymaking process. Governments are catching up.

The lessons, while by no means complete, are sufficiently broad to be applied to multiple common global problems that fit certain characteristics. An important caveat is that we have only used in the paper knowledge from economics to discuss COVID-19 vis à vis climate change from the point of view of conceptual structure as well as of policy management. No insights from other sciences, either life or social sciences, were used. Our ambition in this paper was, in this sense, limited.

Does this paper have an expiration date? We think not. If COVID-19 were to magically disappear, the same arguments could be applicable to the pandemics to come. Moreover, with globalization in retreat, the problem of cooperation between countries to tackle global problems will remain an important policy issue for time to come.

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