



This article forms part of the Special Issue on the Centenary of Chris Freeman's Birth

On the syndemic nature of crises: A Freeman perspective

Giovanni Dosi^a, Luc Soete^{b,*}

^a Institute of Economics, EMbeDS, Scuola Superiore Sant'Anna, Pisa, Italy

^b UNU-MERIT, Maastricht University, Netherlands and Brussels School of Governance, VUB, Belgium

ARTICLE INFO

Keywords:

Syndemics
Impact of the COVID-19 health crisis
Long term environmental crisis
Science
Technology and innovation policy
Education and distant learning
Impact of crises on social and inter-generational inequality

ABSTRACT

In this paper we draw a parallel between the insights developed within the framework of the current COVID-19 health crisis and the views and insights developed with respect to the long term environmental crisis, the implications for science, technology and innovation (STI) policy, Christopher Freeman analyzed already in the early 90's. With at the time of writing, the COVID-19 pandemic entering in many countries a third wave with a very differentiated implementation path of vaccination across rich and poor countries, drawing such a parallel remains of course a relatively speculative exercise. Nevertheless, based on the available evidence of the first wave of the pandemic, we feel confident that some lessons from the current health crisis and its parallels with the long-term environmental crisis can be drawn. The COVID-19 pandemic has also been described as a "syndemic": a term popular in medical anthropology which marries the concept of 'synergy' with 'epidemic' and provides conceptually an interesting background for these posthumous Freeman reflections on crises. The COVID-19 crisis affects citizens in very different and disproportionate ways. It results not only in rising structural inequalities among social groups and classes, but also among generations. In the paper, we focus on the growing inequality within two particular groups: youngsters and the impact of COVID-19 on learning and the organization of education; and as mirror picture, the elderly many of whom witnessed despite strict confinement in long-term care facilities, high mortality following the COVID-19 outbreak. From a Freeman perspective, these inequality consequences of the current COVID-19 health crisis call for new social STI policies: for a new "corona version" of inclusion versus exclusion.

1. Introduction

Christopher Freeman's work offers an in-depth, historical perspective on how processes of technological change affected the historical dynamics of whole societies and, together, the internal organization of work within firms,¹ altered the competitiveness of sectors² and shifted over the long term the position of countries' technological leadership.³ Doing so, he was always at pains to insist that such processes of change

were not technologically given but shaped by the choices made. Choices that are made by individuals: scientists, engineers, entrepreneurs; by firms, both incumbents and new firms; and choices made by society, through political debate, technological assessment and, last but not least, social conflict. "The technology in itself is neither good nor bad", he used to say, "It is the use which human beings make of any technology which determines both the nature and extent of the benefits." (Freeman in HLEG, 1996).⁴ Behind this vision of technology, often in

We are particularly grateful to Ed Steinmueller and three anonymous referees for critical comments received on an earlier version of this article. Errors and views expressed remain our own.

* Corresponding author.

E-mail address: l.soete@maastrichtuniversity.nl (L. Soete).

¹ Following Schumpeter, Freeman always insisted on the interdependence of organizational innovations and technical innovations.

² See e.g. Freeman's earlier work for the National Institute of Economic and Social Research on plastics (Freeman et al., 1963), the emergence of the electronics industry (Freeman, 1965) or the innovation process in chemical process plants (Freeman, 1968), and of course Freeman's first edition of the Economics of Industrial Innovation (Freeman, 1974).

³ As in his book on the emergence of Japanese technological leadership (Freeman, 1987a) for which he received the first Schumpeter Prize in 1988.

⁴ And the quote continues: "Moreover, these do not accrue automatically to everyone in society. For most innovations, both benefits and costs are unevenly distributed. While some individuals and groups may benefit greatly, others may be seriously disadvantaged, through for example, loss of employment or erosion of skills." Freeman quote in the High Level Expert Group on the Information Society, 1996, page i.

<https://doi.org/10.1016/j.respol.2021.104393>

Received 3 March 2021; Received in revised form 16 September 2021; Accepted 27 September 2021

Available online 13 October 2021

0048-7333/© 2021 Elsevier B.V. All rights reserved.

sharp contrast to many of the technological deterministic gloom visions popular during his life and still today, as in many so-called “future studies” (old and recent) on robotics, the future of work or even the limits to growth, one would ultimately always be confronted with Freeman’s strong belief in the possibility, even if not the inevitability, for humans to improve the nature of living and well-being.

With hindsight, it undoubtedly explains the popularity of many of Freeman’s writings at moments of crisis. One may think of his contribution in the late 70’s to the OECD debate on the end of the rapid, post-war growth phase⁵ of OECD countries following the oil crisis, or in the 80’s to the nature of unemployment, following the outburst of unemployment in Europe and the growing fear of employment “displacement” resulting from automation.⁶ Doing so, each time he highlighted how research and innovation policies could become essential for addressing new emerging societal challenges, such as his recognition in the early 90’s of the importance of mission-oriented innovation policies for the greening of technological change to succeed,⁷ or in the late 90’s his particular emphasis on inclusiveness in any future digital society, tackling the potentially disruptive social nature of what was then called “the information society”.⁸

In this paper, we revisit these Freeman “crisis reflections” within the context of the current COVID-19 crisis. Time will tell, but today, the COVID-19 pandemic appears unique in modern times: a global health crisis with major, world-wide economic impacts. As in previous cases, “gloom and doom” fears dominate and are reflected in fears of world-wide recession, unemployment and major disruptions in international trade flows. But also, and more specifically in the prospect of rapidly rising inequalities between individuals, firms, sectors and countries, some benefitting from the crisis and others suffering disproportionately from the lockdown measures taken.

Exploiting a term common in medical anthropology, the editor of the *Lancet*, Richard Horton, has claimed that COVID 19 is less a pandemic than a “*syndemic*”: a new virus interacting with other “non-communicable” diseases clustering the health outcomes in rather differentiated, unequal ways.⁹ The idea that the current COVID-19 health crisis interacts and will be clustered within particular social groups whereby social and economic disparities are likely to exacerbate adverse health effects is very much in line with Chris Freeman’s writings on crises. We build and expand on this notion of “syndemics”,¹⁰ a term that marries

⁵ See Freeman’s devastating critique of the so-called McCracken report, with hindsight possibly *too* devastating (McCracken et al., 1977) in Freeman, 1977.

⁶ See Freeman, Clark and Soete, 1982. Actually, Freeman systematically tried to avoid the word “automation” in describing the impact of information technology on employment.

⁷ See amongst others Freeman, 1992 and Freeman’s contribution to the so-called Maastricht Manifesto (Soete and Arundel, 1993).

⁸ See the book *Work for All or Mass Unemployment? Computerised technical change into the 21st century* (Freeman and Soete, 1994) and the report of the High Level Expert Group on the Information society for the European Commission published in 1996 (HLEG, 1996).

⁹ “Two categories of disease are interacting within specific populations—infection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and an array of non-communicable diseases (NCDs). These conditions are clustering within social groups according to patterns of inequality deeply embedded in our societies. The aggregation of these diseases on a background of social and economic disparity exacerbates the adverse effects of each separate disease. COVID-19 is not a pandemic. It is a syndemic. The syndemic nature of the threat we face means that a more nuanced approach is needed if we are to protect the health of our communities.” Richard Horton (2020).

¹⁰ “a syndemic approach recognizes that diseases in a population occur neither independent of social and ecological conditions, nor in isolation from other diseases... the syndemic concept emphasizes the ways that social conditions and relationships shape disease processes, including contagion, through political-economic, structural, and environmental factors.” Singer and Rylko-Bauer (2021), p. 8-9.

the concept of ‘synergy’ with ‘epidemic’, as background for these Freeman inspired reflections on crises.

In a first section we draw a parallel between the new insights developed within the framework of the current COVID-19 health crisis and the views and insights developed with respect to the other, long-term environmental crisis, the implications for science, technology and innovation (STI) policy Freeman analyzed already in the early 90’s.¹¹ At the time of writing, the COVID-19 pandemic has entered many countries in a third wave with vast differences in the rates of vaccination across rich and poor countries, a situation that suggests the crisis will continue into the long term. Based on the available evidence of the first and second waves of the pandemic, we feel confident that some lessons from the current health crisis and its parallels with the long-term environmental crisis can be drawn although these are necessarily somewhat speculative.

In a second section, we turn to some of the broader, long-term Schumpeterian creative destruction impacts of the COVID-19 crisis. To what extent does the current crisis, with the introduction of generic “equal for all” confinement measures, affect citizens very differently according to their respective working conditions, very unequally in received income or disposal savings and very unfairly in citizens’ life expectancies? In short, the COVID-19 crisis affects citizens in different and disproportionate ways.¹² As a result, the current crisis is not only resulting in rising structural inequalities among social groups and classes, but also to lasting structural inequalities among generations and amongst citizen with different perspectives on the future. We focus on the growing inequality within two particular groups: youngsters and the impact of COVID-19 on learning and the organization of education and on the elderly, many of whom experienced, despite strict confinement in long-term care facilities, high mortality following the COVID-19 outbreak. From a Freeman perspective, these inequality consequences of the current COVID-19 health crisis call for new social STI policies: for a new “corona version” of inclusion versus exclusion.

Time is a central feature in Freeman’s writings, as in his book with Francisco Louçã, *As Time Goes By* (Freeman and Louçã, 2001) where the passage of time leads to tipping points at which drastic changes transform the economy and society as in the case of the Kondratieff long waves. Both COVID-19 and the environmental crisis present us today with striking illustrations of tipping points each within very different time horizons. Both represent striking illustrations of non-linear dynamics with a multitude of cascading effects creating major uncertainties.¹³

1 Short-term versus long-term crises: lessons from the COVID-19 pandemic for the environmental crisis

Crises bring out “fear” in people, something with which Freeman was familiar. Having witnessed himself Fascism, Nazism and war at first hand, he realized better than anyone, how “fear” would lead one to hang on to habits, search for certainty sometimes in authoritarian regimes as well as induce social effects such as polarization, the growth of intolerance, even hate.

In this section, we first briefly discuss the sudden emergence of the ongoing COVID-19 health crisis. We then turn to the debate on the environment and climate change: a long term series of developments

¹¹ Many of these writings were assembled in Freeman’s book on the *Economics of Hope* (1992).

¹² For a more detailed analysis of the Italian case see Dosi and Virgillito (2020).

¹³ As Freeman once put it, commenting on OECD’s long term growth predictions and expressing his sympathy for Kondratieff’s long waves: “a trend is a trend until it bends”.

that are the subject of a huge literature but which only recently have been proclaimed a “crisis”¹⁴. In a final part, we draw some lessons comparing those two crises.

1.1. The COVID-19 health crisis: taking everybody by surprise

Even though the COVID-19 pandemic caught policy makers by surprise, from a historical perspective the emergence of a global pandemic was not something coming out of the blue. There had been various warning signs that, contrary to previous 21st Century pandemics such as SARS, MERS or Ebola, a new virus health outbreak might have a much faster, global impact than anything one had seen before, given the increasingly interlinked nature of human activities across the globe. As is today generally acknowledged, most countries, including the richest, most developed countries in the world were totally unprepared on how to deal with the outbreak of a global pandemic such as COVID-19.

At the same time, the new SARS-COV-2 virus¹⁵ spread into Western societies which were already characterized by a fragility of their social architecture and by major imbalances in their economic and technological dynamism. Looking at the emergence of the COVID-19 pandemic from a more “Freeman like”, macro-economic, historical perspective, it is interesting to observe that the 21st century spread of the COVID health crisis occurred in the context of a major switch in growth from the West to the East and followed a prolonged deterioration of public health services after the thirty “glorious years” of post-war capitalism marked by the conjunction of the rise of fanatic liberalism (Reagan and Thatcher) and the fall of the Soviet Union.¹⁶ Second, the COVID-19 pandemic also hit countries which had barely recovered from the 2008 financial crisis which had turned from a financial crash into a “great recession” to which at best, as in the United States, attempts had been made to return to a situation of “normality” using Keynesian fiscal policies, and at worst, as in Europe, fiscal austerity policies, leading to anemic growth in the stronger European countries and persistent stagnation in the others.¹⁷

From this longer term, historical perspective, it was not surprising that the COVID-19 pandemic, after its initial underestimation, exploded, particularly in Western societies, creating collective panic and disorder. The first wave of COVID-19 infections seemed to form a short-circuit with what in retrospect can only be described as incompetence of political classes, which in the presence of poorly maintained (public) health systems, either ignored the severity of the pandemic or alternatively, hiding behind scientific advice, resorted to the simplest or crudest policy responses. Generic lockdown measures, including school closure, were taken with often an extremely painful impact in social terms, and because of their generic nature were not always very effective from a long-term epidemiological point of view,¹⁸ whereas more simple measures such as wearing nose and mouth masks, routinely introduced in Eastern societies, were at the outbreak of the pandemic ignored.

From an economic point of view, the response to the COVID-19 pandemic by national authorities became stronger over time. The immediacy of the health crisis narrowed the policy focus to shorter term and more local measures. Confronted with an immediate, national

health crisis, old notions of fiscal restraint disappeared in most Western societies leading to an explosion of public debt. With the development of vaccines, a process of international competition in the development, access and rapid distribution across national populations emerged, opening a new window of political relevance for policymakers: what one could describe as health nationalism with international solidarity in the access to vaccines becoming, at best, part of a new form of health diplomacy. To quote the strategic advisor to the Coalition for Epidemic Preparedness Innovations (CEPI): “Once vaccines were successfully developed, a new market emerged and everybody wanted to do a deal - first for themselves, then leaving a bit on the side for the rest of the world. We cannot blame politicians for this behavior, as after all, it is their responsibility and duty to protect their people, and there were no pre-agreements on how we should deal with this situation.”¹⁹,

From a geographic point of view as in the case of the environmental crisis, it seems logical to focus on the specific regions where COVID-19 found a particularly welcoming ‘breeding ground’. Virology or epidemiological microanalysis will be on the physical contact stream of infected individuals; at a more macro level, the focus will be on the regional environmental characteristics for ‘welcoming’ a COVID-19 outbreak.²⁰ Through ‘hot spots,’ e.g. a large social event at a particular location, an unnoticed virus which had already infected a number of individuals could spread locally very quickly. Most surprising from this perspective is the observation that nursing homes became ideal breeding grounds for COVID-19 illness and mortality. The elderly residents in these homes had not travelled to hot spots such as Northern Italy or been to large social events, but they were ideal ‘breeding ground’ for COVID-19. Old age, and in particular older men, having suffered or suffering from lung and heart diseases such as COPD, diabetes and high blood pressure appeared to be the most ‘susceptible population’ for becoming seriously ill with COVID-19. The tragedy of nursing homes was created by the combination of close contact needed for care and a very vulnerable population group. One can only imagine what a virus²¹ that would have affected children and was as highly contagious would have done to day care centres and schools.

In the model developed in Bellomo et al. (2021) in which one of us participated, an attempt was made to introduce heterogeneity of individuals and local interactions on the impact of COVID-19 contamination, allowing for the difference between occasional contacts, occurring e.g. along a street or in a pub, and structured contacts, occurring at home, in hospitals or nursing homes. The results fit well with some of the recent empirical evidence presented in Bendavid et al. (2021). In the Bellomo et al. model,²² strict lockdown policies have opposing effects: they reduce the overall contamination rate in the case of occasional contacts but have the opposite effect of increasing contamination for structured contacts. These results fit well the anecdotal evidence from the second wave whereby under increasingly strict lockdown measures, contamination rates continued to remain stubbornly high at home, in hospitals and nursing homes. Only with generalized vaccination in nursing homes did illness and mortality from COVID-19 start to decline.

¹⁴ The use of the word “crisis” to describe climate change and global warming was popularized by the large number of scientists signing a January 2020 *BioScience* article that formally stated: “the climate crisis has arrived”. (Ripple et al., 2020).

¹⁵ The initial name SARS-COV-2 was chosen because of the genetic relation of the virus that causes the COVID 19 disease and pandemic to the virus responsible for the SARS pandemic, perhaps in hopes that its impact would be similar.

¹⁶ See e.g. Freeman, 2001a.

¹⁷ A trend neatly described in Freeman’s *Science and Public Policy* pamphlet “If I ruled the world” (Freeman, 2001b).

¹⁸ For an in-depth empirical analysis questioning the impact e.g. of strict confinement measures on the spread of COVID-19, see Bendavid, E. Oh, J. Bhattacharya, J. and J. Ioannidis (2021).

¹⁹ Debruyne, L. (2021), “How to be prepared next time: perspectives on the global pandemic response”, *Frontiers Policy Labs, Evidence Snapshots*, see [How to be prepared next time — Frontiers Policy Labs \(frontiersin.org\)](#)

²⁰ Thus, and limiting the analysis to the first wave in Europe, in the Northern Italy case it is likely that it is not the first hospitalised case in Codogno that is relevant, but rather the ‘super-spreading’ event: the Champions League game between Atalanta against Seville in Milan the day before with more than 40,000 Atalanta supporters from Bergamo. Similarly, the French outbreak had less to do with the first case identified in Bordeaux but with a religious event in Mulhouse at the Christian Open Door from 17th to 21st February 2020. Carnival also played a significant role in the spreading of COVID-19 in the Dutch region of Noord-Brabant. See in more detail Soete (2020).

²¹ measles used to be such a virus.

²² For a further elaboration, see also Aguiar et al. (2021).

Interestingly from this perspective the short-term Covid-19 health crisis is likely to have more long-term social ramifications, than economic short-term impacts. These include the role of the state in the economy, the organization of work and education, the value of proximity versus the cost of mobility, to name a few. The COVID-19 health crisis has highlighted the need for new ways of doing business such as teleworking, virtual meetings, distance learning or the reshoring of supply chains. In the case of Europe, this includes new ways of organizing governance in a more complementary way between what appeared to be too complex, multi-levels of European, national and regional cum local decision-making. In a Freeman-like fashion, we focus in Section 2 on some of these broader, long-term social impacts of the current COVID-19 crisis.

Before doing so, let us briefly review some of the most salient aspects of the long-term environmental crisis and the required science, technology and innovation (STI) response as highlighted by Freeman and many other STI scholars.

1.2. Addressing the environmental crisis: from awareness towards directing STI towards sustainability

Already in the late 80's, and possibly triggered by his own critique and that of his colleagues at SPRU²³ on the *Limits to Growth* Report of the Club of Rome (Meadows et al., 1972), Freeman had systematically started to draw particular attention to the need for action with respect to the various negative, environmental aspects of economic growth and development. Following on from this critique, the STI policy focus had to shift towards the particular role of science, technology and in particular its diffusion in addressing those negative externalities: "greening" technology and innovation as he put it.²⁴ Doing so, Freeman also argued in favor of developing a new sort of "missions" to guide the direction of such green STI efforts. He was at pains though to highlight the difference of these new missions with earlier notions of military and space missions. To quote Freeman himself from his written contribution to the so-called Maastricht Manifesto prepared for the European Commission in 1993: "Superficially, this requires a return to the emphasis in the 1950s and 1960s on public goals that were met through mission-oriented projects. However, there is a fundamental difference between older mission-oriented projects, for example nuclear, defense, and aerospace programmes, and new projects to support environmentally sustainable development. The older projects developed radically new technologies through government procurement projects that were largely isolated from the rest of the economy, though they frequently affected the structure of related industries and could lead to new spin-off technologies that had widespread effects on other sectors. In contrast, mission-oriented environmental projects will need to combine procurement with many other policies in order to have pervasive effects on the entire structure of production and consumption within an economy."²⁵ Table 1 from this Manifesto illustrates the main difference between those two mission approaches.

For Freeman, there was in the policy approach to sustainable technologies need for detailed "systemic" knowledge on the congruence of both organizational and institutional change for the diffusion of new technologies to succeed.

Regretfully, like many other contributions in pre-Internet times, these publications on the need to govern the directionality in science and technology – an issue which had already been raised in the 60's by one of

²³ See Freeman, C., Cole, H.S.D., Jahoda, K.L.R., Pavitt, K., 1973

²⁴ He supervised the PhD thesis of René Kemp while at MERIT who focused on the need to give direction to science and technology: for a "greening" of technology, see amongst others (Kemp and Soete, 1990; Freeman, 1992; Kemp 1994.

²⁵ See Soete and Arundel, 1993, p. 50.

Table 1
Characteristics of Old and New "Mission-Oriented" Projects.

Old: defense, Nuclear and Aerospace	New: Environmental Technologies
The mission is defined in terms of the number of technical achievements with little regard to their economic feasibility.	The mission defined in terms of economically feasible technical solutions to particular environmental problems.
<ul style="list-style-type: none"> ● The goals and the direction of technological development are defined in advance by a small group of experts. ● Centralized control within a government administration. ● Diffusion of the results outside of the core of participants is of minor importance or actively discouraged. ● Limited to a small group of firms that can participate owing to the emphasis on a small number of radical technologies. ● Self-contained projects with little need for complementary policies and scant attention paid to coherence. 	<ul style="list-style-type: none"> ● The direction of technical change is influenced by a wide range of actors including government, private firms and consumer groups. ● Decentralized control with a large number of involved agents. ● Diffusion of the results is a central goal and is actively encouraged. ● An emphasis on the incrementalistic development of both radical and incremental innovations in order to permit a large number of firms to participate. ● Complementary policies are vital for success and close attention is paid to coherence with other goals.

Source: Soete and Arundel, 1993, p. 50.

Chris Freeman's closest colleagues, Richard Nelson²⁶ and which had been brought into the policy debate most explicitly in Nelson's book – "The Moon and the Ghetto"²⁷ – went by and large unnoticed. Not that there was any denial of the nature of the environmental crisis, as happened later on with the Copenhagen group around Bjorn Lomborg²⁸ and other climate sceptics. Rather it was the long term nature of the crisis with its disconnect between the lifespan of a human and the time horizon of the biophysical world which meant that postponement and inaction became dominant amongst both policy makers and the business community in the 90's.

Clearly in policy making, short sightedness or rather near sightedness is common because life expectancy, let alone political life expectancy, is particularly short compared to the non-human timescale of biophysical processes. Even more so when the neglect is fostered by powerful economic interests

At the same time, when confronted with long term crises, it is in the nature of humans to adapt: the point of reference of the environmental state of the world renewing itself with each new generation finding it each time "normal" to live in a less biodiverse, more degraded environment.

We are now at a turning point in what scholars have called the *anthropocene* era²⁹ with a very serious possibility of massive reduction in biodiversity and the frequent occurrence of pandemics threatening the very survival of human civilization. It has also been convincingly argued that pandemics and the emergence of the anthropocene era are closely linked.³⁰ Comparing the two crises and in particular the policy responses might provide us with some useful insights. It is to this comparison that we turn now.

²⁶ See Nelson, 1962.

²⁷ See Nelson, 1977 raising the question "why societies so rich and capable technologically and organizationally as to be able to land a man on the moon seemed unable to deal effectively with e.g. poverty, illiteracy, slums." It has been an issue which Richard Nelson has often returned to, see amongst others *The Moon and the Ghetto Revisited* (Nelson, 2011) in which he focused explicitly on the question whether progress could be made "by reorienting our innovation systems?"

²⁸ See e.g. the recent publication of Lomborg (2020).

²⁹ See Crutzen and Stoemer, 2000.

³⁰ See amongst others Coriat, 2020 and also the 2018 report of the Lancet Countdown on health and climate change, written well before the COVID-19 pandemic (Watts, N. et al. 2018).

1.3. The COVID-19 pandemic: a time and space compressed crisis

Compared to the long-term environmental crisis, the COVID-19 pandemic illustrates the short-term impact of a major disruption. “Fear” of contamination, of illness and potential mortality coupled with limits to existing health facilities and, in particular, the prospect of Intensive Care Unit capacities being overwhelmed led to immediate and often dramatic actions to restrict the freedom of individuals in a wide range of activities. The outbreak of the COVID-19 pandemic and the resulting policy (in)actions represent to some extent a unique, time compressed, “pilot” of what may be expected in the arrival of environmental crises.

Most noticeably, the occurrence of the Covid-19 pandemic reinforced dramatically the national context as the dominant policy framework for science-related health policies.

On a more positive note, if the Covid-19 pandemic has reinforced national approaches to health policy, it had the opposite effect on scientific research communities specializing in molecular biology and immunology, which mobilized globally. Medical researchers became frontrunners in the use of open access, the sharing of data and the exchange of information on clinical testing of candidate vaccines. Scientific facts and evidence became the basis for public trust in the face of disinformation campaigns, a situation that climate scientists, confronted with disinformation campaigns for decades, would only be able to dream about.

This common scientific framework did, however, not prevent national health policy advice from applying a myriad of different lockdown policies across Europe and the United States at the start of the outbreak in March 2020 that have sown disorder at European level. The diversity in confinement policies illustrated well the intrinsic limits of ‘science for policy’ in crisis situations. The scientific rationale is based, at least in principle, on the search for a truth (even if not totally exempt from ideological biases). However, the political rationale is based, at best, on values, hence it is pluralistic, and, not rarely, based on prejudice and myths. In Europe, the political rationale appeared also to be culturally pluralistic with very different responses in terms of social behavior. The dialog between scientific and political rationales led to very different outcomes in the first outbreak of the pandemic, ranging from highly restrictive to relatively relaxed confinements of the population.³¹ In the second and third wave, the fear of an uncontrollable spread of the pandemic, including new varieties of the virus, on the eve of implementation of widespread vaccination became the main driving force behind increasingly strict confinement policies.

Yuval Hariri described humanity’s battle with the COVID-19 pandemic as “a scientific triumph coupled with a political fiasco.”³² One of the reasons of this political fiasco was undoubtedly the focus of current virology and epidemiological based approaches on the contamination and spreading of the virus within a national setting with the ‘rest of the world’ treated as an exogenous source of additional hazard. For years now, epidemiological studies have taken individual countries as ‘containers’ for data collection and data analysis. The national setting also provides the framework for estimating the capacity of medical facilities, especially the total number of available intensive care units needed to handle COVID-19 patients.

The measurement of the pandemic and capacity of medical infrastructure are therefore organized within the boundaries of individual states. In the case of Europe, this explains why national health prerogatives became so dominant, in line with the national funding of social and health security. It was the national scarcity of intensive care facilities that became the red line for introducing various national

confinement policies and even “science for policy” advice³³ organized by taking the state as measurement unit. In short, COVID 19 as short-term global health crisis brought into play a return to the national prerogative of the state. In moments of sudden, immediate crises, people turn to national authority with various forms of xenophobia entering as hidden “vermin” in the political discourse: the Chinese virus; the British, South-African, Brazilian, Indian variants; the closure of borders.

The question to be raised is of course whether similar responses might be expected in the case of the climate crisis.

In both cases – COVID-19 and the environmental crisis – the “local dimension” concerns only the surface of the problem while the *deeper drivers are global*. Together, the COVID-19 crisis and the environmental crisis, bring to the fore that crises might be observed first and foremost locally but that their impact rarely remains local and will, given the current context of a highly interlinked global economic world, become naturally global in nature, respecting no boundaries. It is on the side of the COVID-19 pandemic the driving force behind the need for vaccination at global level if one wants to be in a position to eradicate fully all new variants of the SARS-CoV-2 virus. This holds paradoxically today most for countries who had been particularly successful in limiting the spread of the virus during the first wave such as New Zealand, Australia, Japan, Taiwan or Vietnam who were COVID-19 champions during the first wave thanks to strict confinement measures and relative isolation. The successful “hammer policies” of crushing the virus within their borders during the first wave in 2020, means effectively that today population immunity for the virus has remained low and that little priority has been given to fast vaccination because no need was felt in the population to do so. So, paradoxically, even countries with proven effective national confinement policies and as a result low to non-existent COVID-19 contamination rates, find themselves confronted with the need to provide as a matter of priority vaccination to their populations. Barring doing so, means remaining locked out of international contacts and international exchanges. In short, “no corner of the globe is immune from the devastating consequences [of COVID-19, nor – our addition] of climate change” to rephrase a quote from the recent United Nations report *Shaping our Future together*.³⁴

On the other hand, and as in the case of the COVID-19 pandemic, one can expect that increasingly open science will also dominate environmental research. At the same time, the commercial world-wide vaccine market provides insights for the development and diffusion of green industrial technologies. The business model in vaccine production³⁵ typically discriminates between high-income markets for which high prices can be charged even though most of the research involved in the *phase I trial* would be funded through public means from those countries, and subsequently in low-income markets low prices would be charged often at zero profits as part of the Global Alliance for Vaccines (GAVI) established in 2000. GAVI created purchasing procurement power for low-income countries which needed vaccines most often saving the lives of millions of children. The COVID-19 pandemic with the use of new techniques such as sequence analysis and the mRNA platforms dramatically reduced the time for the development and approval of new corona vaccines with high income countries such as the US, the EU and the UK covering many development and regulatory risks. But the global nature of the pandemic meant that once the vaccines were developed and approved, the old vaccine production business model would appear totally inappropriate.

³³ With in each country different national, scientific media heroes.

³⁴ <https://www.un.org/en/un75/climate-crisis-race-we-can-win>

³⁵ For a good overview see <https://ig.ft.com/coronavirus-vaccine-tracker/?areas=gb&areas=us&areas=eu&cumulative=1&doses=full&populationAdjusted=1>

³¹ See also Soete (2020) for a more detailed discussion on the alternative hammer versus nudge set of policies implemented.

³² https://twitter.com/harari_yuval/status/1344538372124143616

From this perspective the current international policy debate³⁶ focuses too narrowly on the world-wide access to the intellectual property behind the global COVID-19 vaccines and too little on the development of production capacity in low-income countries of corona vaccines. As Xiaolan Fu and her colleagues³⁷ put it recently: “Even if the WTO adopts the patent waiver, pharmaceutical companies cannot be forced to share the know-how required to manufacture these vaccines... The US and the EU can incentivize, encourage and engage their pharmaceutical companies to share not only their patents but also their tacit production knowledge with manufacturers across the world through setting up joint ventures with local pharmaceutical companies... This approach may have a more rapid and significant impact on vaccine production than a change in intellectual property right regulation alone.... the Africa Union and the Africa Centres for Diseases Control and Prevention (Africa CDC) have recently proposed the establishment of five pharmaceutical manufacturing hubs to accelerate COVID-19 vaccine manufacturing on the continent”.

The need for a stronger focus on the effective use and application of green technologies, including knowledge transfer in all its forms rather than just waivers for intellectual property, is also what should characterize the diffusion of green technologies to developing countries. Most of these green technologies are in their application primarily process technologies enabling e.g. energy saving, as in housing, or accelerating the transition towards clean energy production and distribution. As in the case of vaccines, efficiency gains, e.g. reductions in CO2 emissions, are often most significant in low-income countries allowing for processes of sustainable development based on grassroots innovation exploiting also local, informal knowledge. By contrast, in high-income countries, the costs of transition from the long incumbent, centralized, fossil-fuel dependent energy production and distribution networks are likely to be high with large parts of industry (from oil to steel, cement, chemicals, motor cars, aircraft, etc.) locked into fossil fuel dependent energy provision. Not surprisingly, the current new “green deals” in both the EU and the US, designed to support national industries in their energy transition, involve astronomical amounts of public funds being earmarked for such transition.³⁸

From a global perspective, the idea that national or supra-regional “green deals” in high income countries will be sufficient to contribute to the global climate crisis while at the same time contributing to those countries’ “green competitiveness” is very much open to debate. If “green competitiveness” can be translated across the globe in local, clean energy transition and circular economy principles, irrespective of the high versus low-income location, global value chains will emerge contributing to global sustainable development. If not, growing inequality and global unsustainable development will undermine most countries’ attempt at green competitiveness.

³⁶ As the Independent Panel for Pandemic Preparedness and Response recommended in its **COVID-19: make it the last pandemic** report proposed: “The World Trade Organization (WTO) and WHO should convene major vaccine-producing countries and manufacturers to agree to voluntary licensing and technology transfer for COVID-19 vaccines. If actions do not occur within three months, a waiver of intellectual property rights under the Agreement on Trade-Related Aspects of Intellectual Property Rights should come into force immediately.”

³⁷ Xiaolan Fu, Diego Sanchez-Ancochea, Ines Hassan, Peter Buckley (2021), *The world has a unique opportunity: Accelerating technology transfer and vaccine production through partnerships*, mimeo.

³⁸ At the same time, such transition will be crucially dependent on how CO2 and other emissions will be priced providing room to new green technologies to become profitable. From this perspective, the trend in the EU’s Emissions Trading System (ETS) carbon price that has recently hit a record of just above €50 per tonne is interesting. One may expect that this price will further increase in the coming years triggering further investments in innovative clean technologies

2. A Freeman perspective: creative destruction and disruptive creation responses to the COVID-19 crisis

Analytically, the exponential, systemic spreading of COVID-19 and its “syndemic” interaction with local socioeconomic conditions, has a lot in common with the diffusion process of one or a cluster of radical innovations. For Freeman such diffusion processes would be accompanied by major structural changes, by skill mismatches and unemployment. As he put it: “For most innovations, both benefits and costs are unevenly distributed. While some individuals and groups may benefit greatly, others may be seriously disadvantaged...”.³⁹ In a paper on “place-based innovation and sustainability” written at the time of the outbreak of the COVID-19,⁴⁰ one of us put forward a number of speculative reflections on the “syndemic” insights for innovation diffusion theory following the COVID-19 crisis. “Once the current corona crisis is over, one will be able to learn a great deal from the differentiated regional impact of the corona virus outbreak. One may think of topological as well as structural variables such as population density, its age and health but also other, more behavioral variables such as cultural, food and drinking habits... To list just a few: one may wonder to what extent the particular local “breeding ground” of sustainable innovations might be inductive to a more rapid diffusion of innovations and to what extent one can create conditions in regions’ and locations’ situations of “super-propagation” of sustainable innovation? What role do particular communities play in such propagation, locally or elsewhere? Can one detect or calculate, as in the case of the corona virus, a “reproductive number” above which the diffusion of innovation might be more or less automatic not needing any specific diffusion policy support; or by contrast, is there a level at which innovations will not diffuse and even fade away? How is the diffusion process accompanied by changes and adaptations of the innovation itself, in function of the interaction with the local environments in which the innovation spreads?” [McCann and Soete, 2020, p. 6]

In short, epidemiology and diffusion have a lot in common. The fundamental policy difference is of course the attempt, as in the case of the COVID-19 pandemic, to restrict as much as possible, ideally to eradicate, the diffusion of the SARS-COV-2 virus whereas in the case of sustainable innovations and green technologies, the aim is the opposite. In both cases though, the measures taken: confinement, lockdown, closure of schools, limiting mobility on the one hand versus freedom to experiment as in the case of regulatory “sandboxes” and innovation testbeds on the other hand, are likely to accelerate new forms of organizational innovation. In the first case as a result of the restrictions enforcing social distancing undermining e.g. the provision and delivery of services which crucially depended on physical contact and social interaction. In the second case more as a result of the inertia of regulation: the so-called “pacing problem” faced by regulation confronted with rapid technological change as e.g. in the case of the digital transformation of sectors traditionally heavily regulated, such as telecommunications, health or energy.

Undoubtedly, in many of the areas where physical contact is the essence of the service, one can expect a gradual return to “normal” following successful vaccination. But in others, the new, virtual alternative organization forms which already existed, but were not widely diffused, are likely, after the COVID-19 crisis, to persist. The dramatic growth in delivery of goods and services – with some restaurants becoming catering kitchens – is probably the most concrete example. From this perspective, the COVID-19 pandemic led to rediscovery of the value of proximity. It has increased the value of local physical contact at the expense of distant contact. Think of the cost of commuting or travelling with online work or online meetings taking off, shifting radically the “workplace” from a distance to a local environment.

In this section, we first focus on one such area of physical contact,

³⁹ Freeman quote in HLEG. 1996, op.cit

⁴⁰ McCann and Soete (2020).

non-market service delivery which was abruptly subject to social distancing and forced to re-organize itself in virtual ways: education. Following the second wave of COVID-19 contamination, there is today widespread agreement that youngsters, and in particular those subject to schooling, have suffered most from lockdown measures, which included the closure of schools and the provision of digital teaching. As in a “syndemic” version of the COVID-19 pandemic’s interaction with learning, the existing digital divide was exacerbated by existing inequalities: inequalities not just in the access to high-speed internet connection and ICT-devices but also inequalities in the education levels of parents, in social and housing family conditions. In short, schools have never been as unequal as they were in pandemic conditions. As Richard Baldwin pointed out, quoting a recent UN report: “the COVID-19 pandemic has created the largest disruption of education systems in history, affecting nearly 1.6 billion learners in more than 190 countries and all continents. Closures of schools and other learning spaces have impacted 94% of the world’s student population, up to 99% in low and lower-middle income countries.”⁴¹ In many ways, youngsters represent the long-term collateral damage of too generic lockdown measures.

In a second part, we discuss the impact of the COVID-19 pandemic on the elderly. In particular, the impact on the elderly often living in nursing homes, in so-called long term care facilities. Many of those paid a high, sometimes fatal, price in their health. On a more cynical note, it explains why the aggregate economic impact of the COVID-19 pandemic, compared to earlier pandemics has been limited. As [Bel-lomo et al. \(2021\)](#) put it: “notwithstanding heterogeneity across countries, in general it is not likely to expect the pandemic impacting on labor supply to a magnitude recalling the Black Death or even the Spanish Flu. Together, this pandemic, unlike other historical episodes such as the Plague of the 14th century, will not serve to alleviate income and wealth inequalities, by increasing the wages of a scarce labor force and reducing the value of real estates on sale for the death of their primary owner... given the concentrated direct impact on the elderly population, one might not consider any direct economic consequence arising from the death of the elderly. This does not mean that deaths are acceptable because they do not impinge directly on the economic system”. While this representation of the elderly as “*quantité négligeable*” is of course outrageous, the COVID-19 pandemic brings to the fore the need to reassess and revalue the role and function of the elderly in our societies. To the extent that priority has been given to the elderly in countries’ national vaccination strategies, the pressure should now be on finding more inclusive roles for the elderly.

In short, the “syndemic” impact of COVID-19 has been high, affecting both youngsters and elderly in very differentiated ways. While the pandemic has resulted in a crisis in inter-generational justice between on the one hand youngsters locked-out of schools, travel and entertainment and on the other hand retired, elderly people risking high mortality as a result of COVID-19 despite strict confinement in long term care facilities, the long term, creative disruptive features of the organizational changes induced by COVID-19 have, as yet, only begun to be studied and analyzed.

2.1. Making schools and education inclusive

As argued above, youngsters represent in many ways the long-term collateral damage of generic lockdown measures, including in practically all countries long periods of school closure. The costs of the first wave of lockdown measures in 2020 have been estimated by the OECD as: “A learning loss equivalent to one-third of a year of schooling for the current student cohort [is] estimated according to historical growth relationships to mean 1.5% lower GDP on average for the remainder of

the century.”⁴²

At the same time, it is not so much the digital provision of education which is to blame for such damage than the fact that because of the lockdown, schools no longer can play their role of physical meeting place for youngsters to interact and learn to socialize within structured, regular time frames with teachers as both learning authority and knowledge sparring partners and, more generally, to prepare to make life choices. The comparison can be made here with the social psychology study of Marie [Jahoda et al. \(1933\)](#) on the unemployed of Marienthal, often cited by Freeman, who suffered not just economically but primarily mentally, in terms of motivation and life meaning. In the current COVID-19 context, the unemployed now being the “uneducated” pupils and students.

Nonetheless, the COVID-19 pandemic may be contributing to the potential for an education revolution in “blended learning” consisting of more digital teaching facilities exploiting best practice “video-based” teacher performance at national level with schooling establishments focusing more on in-person instruction, and providing the physical environment for application, individual evaluation and social interactions.⁴³

It is here that the comparison with the way organizational change played the major role in the diffusion of electricity during the 1920’s as studied by Freeman is of particular relevance. As [Freeman \(1987b\)](#) and also Paul [David \(1990\)](#) highlighted, the first use and introduction of electricity in manufacturing did not really lead to any productivity gains, the replacement of steam power with electricity leading to similar problems of breakdowns, the electric engines being structured in a similar fashion to steam engines as central energy sources on which all machines dependent. It was only with the discovery of the unit electric drive, i.e. electricity as energy source for each separate machine, that automation and assembly line production could take off. Let us quote Freeman in somewhat more detail: “It was not until after 1900 that manufacturers generally began to realize that the indirect benefits of using unit electric drives were far greater than the direct energy saving benefits. Unit drive gave far greater flexibility in factory layout since machines were no longer placed in line with shafts, making possible big capital savings in floor space. ... Unit drive meant that trolleys and overhead cranes could be used on a large scale unobstructed by shafts, countershafts and belts. Portable power tools increased even further the flexibility and adaptability of production systems. Factories could be made much cleaner and lighter, which was very important in industries such as textiles and printing, both for working conditions and for product quality and process efficiency.” ([Freeman, 1987b](#), p. 60)

In the case of education, it could be argued that the various attempts at introducing information and communication technologies during the COVID-19 crisis, only tried – in a broadly similar fashion to electricity – to imitate the physical classroom now in a digital form with the teacher at a distance and pupils or students listening to each from their home place. In many ways this digital adoption process, imitation might be a better word, where schools organizationally resemble the first phase of Richard [Barras’](#) “reverse product cycle” (1986): a process characteristic of many service sectors whereby digital technologies are first introduced to accomplish back-office work, and only subsequently lead to the creation of new service configurations. In the case of COVID-19, the confinement measures taken led to an explosion of digital replacements across many service sectors: from the digital signing of official documents with accountants to virtual visits of houses with real estate

⁴²

⁴³ As [Hanushek and Woessmann \(2020\)](#) observe: “while it has yet to be analysed rigorously, some teachers are undoubtedly better than others at providing video-based instruction, while others are more effective at providing in-person instruction. Policies that recognise differences in effectiveness and that use more effective teachers in a better manner would improve overall school performance”.

⁴¹ <https://voxeu.org/content/covid-and-international-economic-cooperation-if-not-now-then-when>

brokers. More broadly, the enforced digitalization of public services is creating new digital divides with literate citizens no longer being prepared to consider themselves as the passive recipient of some public services and re-positioning themselves as more active co-producers, and others becoming excluded, at best uninformed of new digital public service opportunities. We limit our analysis here to education.

From an educational, learning perspective the more fundamental question is which learning activities depend on physical (synchronous) presence and at what age, and which activities students can learn through interaction with software, individual reading, or other individual or small group activities. As in Barras' reverse product life cycle model there will be a tendency to focus first on the opportunities for replacement of education in a classroom with digital education, converting the traditional, classic timetable into an online event. Teachers, professors, and students quickly mastered Zoom and Teams video calling by following existing timetables and retaining as much as possible the fifty minutes course or lesson framework.

But as in the case of unit electric drive, the real change in digital education will have to occur through new hybrid forms of education based on pedagogical insights, on digital didactics. Such new hybrid forms will offer more possibilities to differentiate between students combining partial distance learning and contact education allowing for greater diversity at schools, in terms of talents, cognitive skills, maturity, prior knowledge, even language.⁴⁴ In short, making schools and education more inclusive.

At the level of higher education this will be even more pronounced: a 'real' paradigm change in digital education would involve the offer of "best practice" lectures and demonstrations in basic courses, especially in STEM (science, technology, engineering and maths) across higher education institutions, freeing the time of other teachers for doing exercises and assessing the progress of individual students. From this perspective, the MOOCs were a first initial attempt at university level to provide global access to best practice university teaching. They often suffered though from the same, conservative imitation reflex: turning into purely talking heads (reproducing the standard lecture format) and ignoring the possibilities for digital didactics. The design challenge in digital didactics is to activate learning by using the computer as an experiential tool to engage students with the content and even more importantly elicit their participation in reflective and practice-correction cycles where much of learning actually occurs. It is this global model which should now become adapted and integrated more locally in national higher education programmes. Less with the aim of increasing efficiency in higher education but rather with the aim of increasing the quality and inclusiveness of higher education by freeing time for other physical learning activities. In many ways, this would mirror the organizational innovation that occurred with unit electric drive.

The post COVID education system reform should exploit best practice online education to the benefit of a more inclusive school and learning system. Schools – both as an institution as well as a building – represent the last chance not only for social exchanges but also for the promotion of substantial equality. Giving explicitly schools the tasks of providing access to best practice digital education and freeing time for physical face-to-face education addressing "face to face" socially isolated pupils and students from poorer and more marginalized neighborhoods represents our "economics of hope" for a post-COVID-19 world.

2.2. To be or not to be old in COVID-19 times

There is broad agreement that the illness, hospitalization and fatality rates of the COVID-19 pandemic have been closely related to age, health,

as well as other social, even housing vulnerabilities.

The mirror picture of the COVID-19 "syndemic" highly differentiated impacts on education and schooling can be found in the way that the COVID-19 pandemic hit the elderly, particularly those living in nursing homes or "long term care facilities" (LTCF). The difference between countries in the number of COVID-19-related deaths in such care facilities is striking. As of the end of May 2021 the number of COVID related deaths per 100 care beds ranged from 9.3 for Slovenia and 8.3 for Belgium to 0.4 for Finland.

It is here that the concept of "syndemics" takes on its full meaning. It is not just an issue about comorbidity, but a process of "biological and social interactions between conditions and states... that increase a person's susceptibility to harm or worsen their health outcomes"⁴⁵ Particularly in some countries' LTCF, these conditions, despite the strict confinement measures taken, impacted negatively on the welfare of the most vulnerable groups present and ultimately worsened their health situation. As Peter Lloyd-Sherlock (2020), points out: "One of the main points of viral entry into LTCFs has been through care workers, who work part-time across a number of facilities. When one LTCF becomes infected, these workers spread the virus to the others. Often, these women (sic, a (small) number of men also work in LTCF) have no choice other than to work across multiple facilities, since they are part of a low-status, casual workforce. Often, LTCFs prefer not to employ them on a full-time, formal basis. Many are immigrants and from deprived communities. Almost none own cars and so travel from facility to facility on public transport, adding a further risk of infection. They are afraid of being tested, since they may well lose their jobs if found to be positive (and they lack access to adequate social protection). Most have large families who depend on this income and many live in over-crowded environments, which are high-risk infection environments." The outburst of contaminations, and as a result the high fatality rates in LTCF, raises questions as to the way care for the elderly has been organized in Western societies and the extent to which there is in Lloyd-Sherlock's words a need to reconstruct "communities of interest" across ages.⁴⁶

It is an issue which was close to the heart of Chris Freeman, and in particular his close friend and colleague Marie Jahoda, who was always full of ideas on how to address the growing segmentation of generations in Western societies. She emphasized how marriages within the same generation would come under increasing pressure from an inter-generational fairness perspective (Jahoda, 1982). The loneliness of the elderly, highlighted today in a dramatic way in the confinement of elderly in LTCF, illustrates the inter-generational loss of well-being in many Western societies.

Of all living things and species, humans are unique in the sense that they live much older than is actually necessary for their reproduction. Even in the early years of economic development, women have always lived many years after their menopause. Throughout history, older people were cared for in large families and often contributed to the family by caring for children or performing household chores. In short, the elderly always played an important social role, often within an extended family. The decline in the birth rate, as well as the increased mobility of young couples in their collective quest for better career opportunities, deprives the elderly of this social contribution. As a result, their existence seems to have become functionless. The search for "pursuits" which do not provide a social benefit is also associated with an increased lack of social recognition. With age, a vicious circle develops between physical disabilities and mental self-image. As a result, many elderly people fall into depression and loneliness.

The lockdown measures following the COVID-19 pandemic have

⁴⁵ Horton (2020), op. cit. p. 874.

⁴⁶ Lloyd-Sherlock, P. COVID-19 and intergenerational justice: trying to get the bigger picture, <https://corona-older.com/2020/12/11/covid-19-and-intergenerational-justice-trying-to-get-the-bigger-picture/>

⁴⁴ See Yves Demaertelaere 2021 <https://yvesdemaertelaere.com/2021/02/25/leren-heeft-de-school-verlaten/>

exacerbated existing inter-generational inequalities with respect to living time, in particular the balance between past, present and future time. The challenges but also opportunities for organizational change, for reconstructing alternative, new communities of interest across ages not necessarily based on family ties are significant. They also include the development and diffusion of new assistive domotics products, the use of care robots as well as a whole set of “appropriate” products for elderly citizens. So far, the way in which these technologies and much broader organizational innovations might contribute to improved welfare of the elderly during a pandemic, such as COVID-19, is a topic that has received little attention. Yet as highlighted above, the difference between countries in excess mortality in LTCF as a result of COVID-19 is striking and should be a good starting point for such new reflections.

3. Conclusions

The historically unprecedented features of the COVID-19 pandemic highlight the response of many governments and citizens to uncertainty. Radical measures (closing borders, confinement of populations, closure of schools, etc.) were taken, each at national level with the aim to slow the spread of the virus within individual countries’ borders. These decisions, often draconian, were initially less accepted by populations in democratic settings. However, governments succeeded in convincing the public at large of the need for such measures and thus demonstrated their power to act rapidly when confronted with an immediate pandemic crisis that created uncertainty about future health and increased mortality risk. Whether such actions would be introduced in response to crises arising from climate change or drastic erosion of biodiversity, remains to be seen.

Most striking is how the COVID-19 pandemic has offered national policy makers a new window of political relevance: a new form of health nationalism. At the same time the lack of solidarity at global level in the world-wide vaccine distribution has been particularly striking.

In the case of the climate crisis, there is no vaccine.⁴⁷ While there are of course many scientists who believe in the possibilities of finding geo-engineering solutions to the climate crisis, including the large-scale carbon capture/storage and other technology-based fixes, it seems reasonable to assume that contrary to the COVID-19 pandemic, the climate crisis will have to be addressed first and foremost endogenously, not by a “manna from heaven” solution, but by humanity: by all of us. In this respect, the current responses to the COVID-19 crisis teach us a few lessons on what should and what should **not** be done with the environmental crisis.⁴⁸ In conclusion we would stress two:

What should be done is to keep and encourage open science as dominant framework for environmental research, so that intellectual protection on newly developed green technologies prevents as little as possible their widespread diffusion and industrial application globally. The current debate on patent free vaccine production should in other words become part of a broader discussion on patent free access to green industrial technologies. One might even think of the need for institutions such as GAVI or COVAX with respect to green technologies. These industrial technologies can be considered, in the same way as in the case of the COVID-19 pandemic as “essential goods”, now “essential technologies” for addressing the environmental crisis.

⁴⁷ It is unclear who was the first to phrase this slogan. Fazlun Khalid, an advisor to UNEP mentions it an opinion piece on April 15th, 2020 [citation]. Ursula von der Leyen launched her tweet “Sooner or later we will find a vaccine for the #coronavirus. But there is no vaccine for climate change. Therefore, Europe needs a recovery plan designed for the future. [Make this a citation #EPlenary on May 13th, 2020.]

⁴⁸ There is also a general lesson here: wars are too serious a challenge to be left to the market. Best and Beadley (2020) documents how the US had to quickly become successful in emergency conditions by implementing an almost-centrally-planned economy in WW II.

What should not be done, is to further encourage national policy responses focusing on technological sovereignty. While we would welcome, in line with Freeman’s policy perspective that: “mission-oriented environmental projects will need to combine procurement with many other policies in order to have pervasive effects on the entire structure of production and consumption within an economy”,⁴⁹ such as a renewed focus on industrial policy such missions should also prompt international discussions on the access to resulting technologies, the diffusion of which will be essential in addressing global crises.

Despite all the thoughts and reflections detailed above in previous sections, we can ultimately only imagine how Christopher Freeman would have perceived the current global COVID-19 health crisis... Nevertheless, we feel confident that he would have championed novelist Arundhati Roy’s description: “Historically, pandemics have forced humans to break with the past and imagine their world anew. This one [COVID-19] is no different. It is a portal, a gateway between one world and the next. We can choose to walk through it, dragging the carcasses of our prejudice... and dead ideas... Or we can walk through lightly, with little luggage, ready to imagine another world. And ready to fight for it.”⁵⁰

Credit author statement

We are particularly grateful to Ed Steinmueller and three anonymous referees for critical comments received on an earlier version of this article. Errors and views expressed remain our own.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- Aguiar, M., Dosi, G., Knop, D., Virgillito, M.E., 2021. A multiscale network-based model of contagion dynamics: heterogeneity, spatial distancing and vaccination. *Math. Models Methods Appl. Sci.* forthcoming.
- Bellomo, N., Bingham, R., Chaplain, M.A.J., Dosi, G., Forni, G., Knopoff, D.A., Lowengrub, J., Twarock, R., Virgillito, M.E., 2021. A multi-scale model of virus pandemic: heterogeneous, interactive entities in a globally connected world. *Math. Models Methods Appl. Sci.* <https://doi.org/10.1142/S0218202520500323>.
- Bendavid, E., Christopher, O., Bhattacharya, J., Ioannidis, J., 2021. Assessing mandatory stay-at-home and business closure effects on the spread of COVID-19. *Eur. J. Clin. Invest.* <https://doi.org/10.1111/eci.13484>. First published: 05 January 2021.
- Best, M., Beadley, J., 2020. World War II to Covid-19 : Been there Before and Done Better. INET. <https://www.ineteconomics.org/perspectives/blog/world-war-ii-to-covid-19>.
- Coriat, B., 2020. La pandémie, L’anthropocene Et Le Bien Commun. Editions Aux Lieu Qui Libèrent, Paris.
- Crutzen, J., Stoermer, E.F., 2000. The Anthropocene. In: *Global Change Newsletter*, 41. IGCB.
- David, P., 1990. The dynamo and the computer: an historical perspective on the modern productivity paradox. *Am. Econ. Rev.* 80 (2), 355–361. May.
- Demaertelaere, Y. (2021), *Leren heeft de school verlaten* (learning has left the school), <https://yvesdemaertelaere.com/2021/02/25/leren-heeft-de-school-verlaten/>.
- Debruyne, L. (2021), “How to be prepared next time: perspectives on the global pandemic response”, *Frontiers Policy Labs, Evidence Snapshots, How to be prepared next time — Frontiers Policy Labs* (frontiersin.org).
- Dosi, G.L.F., Virgillito, M.E., 2020. Unequal societies in usual times, unjust societies in pandemic ones. *J. Ind. Bus. Econ.* <https://doi.org/10.1007/s40812-020-00173-8> published online July 21st 2020.
- Freeman, C., Fuller, J., Young, A., 1963. The plastics industry: a comparative study of research and innovation. *Natl. Inst. Econ. Rev.* 26, 22–62.
- Freeman, C., 1965. Research and development in electronic capital goods. *Natl. Inst. Econ. Rev.* 34, 40–91.
- Freeman, C., 1968. Chemical process plant: innovation and the world market. *Natl. Inst. Econ. Rev.* 45, 29–51.

⁴⁹ Broadly in line with Mazzucato’s (2018, 2021) recent approach to missions.

⁵⁰ Roy A, 2020.

- Freeman, C., Cole, H.S.D., Jahoda, K.L.R., Pavitt, K., 1973. *Thinking About the Future: A Critique of 'The Limits to Growth*. Chatto and Windus/Sussex University Press, London and Brighton.
- Freeman, C., 1974. *The Economics of Industrial Innovation*. Penguin Books, Harmondsworth.
- Freeman, C., 1977. The Kondratiev long waves, technical change and unemployment. Expert Meeting On Structural Determinants of Employment and Unemployment. OECD, Paris.
- Freeman, C., Clark, J., Soete, L., 1982. Unemployment and Technical innovation: a Study of Long Waves and Economic Development. Pinter, London.
- Freeman, C., 1987a. Technology Policy and Economic Performance: Lessons from Japan. Pinter, London.
- Freeman, C., 1987b. Information technology and change in techno-economic paradigm. In: Freeman, C., Soete, L. (Eds.), *Technical Change and Full Employment*. Basil Blackwell, Oxford, pp. 49–69.
- Freeman, C., Soete, L. (Eds.), 1990. *New Explorations in the Economics of Technological Change*. Pinter, London.
- Freeman, C., 1992. *The Economics of Hope: Essays On Technical Change, Economic Growth and the Environment*. Pinter, London.
- Freeman, C., Louçã, F., 2001. *As Time Goes by: from the Industrial Revolutions to the Information Revolution*. Oxford University Press, Oxford.
- Freeman, C., 2001a. A hard landing for the 'New Economy'? Information technology and the United States national system of innovation. *Struct. Change Econ. Dyn.* 12 (2), 115–139.
- Freeman, C., 2001b. If I Ruled the World. *Sci. Public Policy* 28 (6), 477–479 (December 2001).
- Hanushek, E., Woessmann, L., 2020. *The Economic Impacts of Learning Losses*. OECD, Paris. September.
- High Level Expert Group, 1996. *Building the European Information Society for Us all*, First reflections of the HLEG, Interim Report. European Commission, Brussels. January.
- Horton, R., 2020. Offline: COVID-19 is not a pandemic. *Lancet North Am. Ed.* Vol 396 (September 26), 874.
- Jahoda, M., Lazarsfeld, P.M., Zeisel, H., 1933. *Marienthal: The Sociography of an Unemployed Community*, (English Translation 1972). Tavistock Publications, London.
- Jahoda, M., 1982. *Employment and Unemployment: A Social-Psychological Analysis*. CUP, Cambridge.
- Kemp, R., 1994. Technology and the Transition to Environmental Sustainability. The Problem of Technological Regime Shifts. *Futures* 26 (10), 1023–1046.
- Kemp, R., Soete, L., 1990. Inside the 'green box': on the economics of technological change and the environment. In: Freeman, C., Soete, L. (Eds.), *New Explorations in the Economics of Technological Change*. Pinter, London.
- Lomborg, B., 2020. *False Alarm How Climate Change Panic Costs Us Trillions, Hurts the Poor, and Fails to Fix the Planet*. Basic Books, New York.
- Mazzucato, M., 2018. *Mission-Oriented Research & Innovation in the European Union A problem-Solving Approach to Fuel Innovation-Led Growth*. European Commission, Brussels.
- Mazzucato, M., 2021. *Mission Economy: A Moonshot Guide to Changing Capitalism*. Allen Lane, London.
- McCann, P., Soete, L., 2020. *Place-Based Innovation For Sustainability*. Publications Office of the European Union, Luxembourg doi:10.2760/250023, JRC121271.
- McCracken, P., Carli, G., Giersch, H., Komyia, R., 1977. *Towards Full Employment and Price Stability: a Report to the OECD By a Group of Independent Experts*. OECD, Paris.
- Meadows, D.H., Meadows, D.L., Randers, J., Behrens, W.W., 1972. *The Limits to Growth: a Report For the Club of Rome's Project On the Predicament of Mankind*. Earth Island Ltd, London.
- Nelson, R.R. (Ed.), 1962. *The Rate and Direction of Inventive Activity: Economic and Social Factors*. NBER, New York.
- Nelson, R., 1977. *The Moon and the Ghetto: An Essay On Policy Analysis*. W. W. Norton, New York.
- Nelson, R., 2011. The Moon and the Ghetto Revisited. *Sci. Public Policy* 38 (9), 681–690. November 2011.
- Ripple, W., Wolf, C., Newsome, T., Barnard, P., Moomaw, W., 2020. World scientists' warning of a climate emergency. *Bioscience* 70 (1), 8–12. <https://doi.org/10.1093/biosci/biz088>.
- Roy A. (2020), The pandemic is a portal, <https://www.ft.com/content/10d8f5e8-74eb-11ea-95fe-fcd274e920ca/4> April, *The Financial Times*.
- Singer, M., Rylko-Bauer, B., 2021. The syndemics and structural violence of the COVID Pandemic: anthropological insights on a crisis. *Open Anthropol. Res.* 1, 7–13. <https://doi.org/10.1515/opan-2020-0100>.
- Soete, L., 2020. Hammer Or Nudge? Science based Policy Advice in the COVID-19 Pandemic. *UNU Policy Brief*, May, Tokyo.
- Soete, L., Arundel, A., 1993. *An Integrated Approach to European Innovation and Technology Diffusion Policy: a Maastricht Memorandum*. Commission of the European Communities, Dissemination of Scientific and Technical Knowledge Unit, Directorate-General Information Technologies and Industries, and Telecommunications, Brussels; Luxembourg.
- Watts, N., et al., 2018. The 2018 report of the Lancet Countdown on health and climate change: shaping the health of nations for centuries to come. *Lancet North Am. Ed.* 392 (10163), 2479–2514. [https://doi.org/10.1016/S0140-6736\(18\)32594-7](https://doi.org/10.1016/S0140-6736(18)32594-7), 8 Dec.