Socioecological System Transformation: Lessons from COVID-19

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Abstract: Environmentalists have long warned of a coming shock to the system. COVID-19 exposed fragility in the system and has the potential to result in radical social change. With socioeconomic interruptions cascading through tightly intertwined economic, social, environmental, and political systems, many are not working to find the opportunities for change. Prefigurative politics in communities have demonstrated rapid and successful responses to the pandemic. These successes, and others throughout history, demonstrate that prefigurative politics are important for response to crisis. Given the failure of mainstream environmentalism, we use systemic transformation literature to suggest novel strategies to strengthen cooperative prefigurative politics. In this paper, we look at ways in which COVID-19 shock is leveraged in local and global economic contexts. We also explore how the pandemic has exposed paradoxes of global connectivity and interdependence. While responses shed light on potential lessons for ecological sustainability governance, COVID-19 has also demonstrated the importance of local resilience strategies. We use local manufacturing as an example of a possible localized, yet globally connected, resilience strategy and explore some preliminary data that highlight possible tradeoffs of economic contraction.

1. Introduction

Many environmentalists have long warned of the likelihood of a significant shock to the system given humanity's inability to respond to our ecological emergency. The COVID-19 pandemic has been widely recognized as auguring some kind of turning point in the global social–ecological system. Newspaper pundits talk as if we have crossed some Rubicon. But in our case, there is no Caesar with a clear political agenda. Studies of the dynamics of complex social–ecological systems show that external shocks have the potential to push systems into alternative steady states [1]. It is impossible to know whether the COVID-19 pandemic will trigger such systemic change. But with socioeconomic disruption cascading through tightly coupled economic, ecological, social, and political systems, many are working to turn crisis into opportunity. In this article, we explore (a) the possible impact of systemic change on human and planetary health, and (b) the extent to which the convergent politics of this transition may depend, paradoxically, on the intersection of very different drivers, involving often agonistic players, with little mutual trust and understanding, and certainly no common political vision.

We do this by looking at ways in which the COVID-19 shock has been leveraged in local economic contexts, emphasizing the importance of prosocial forms of economic life and healthcare. The COVID-19 pandemic has exposed the fragility of our systems and has the potential to shock our societies and economies toward an alternative state that could be more conducive to human and planetary health. However, the pandemic also highlights and precipitates the paradoxes of global connectivity and interdependence. While these

approaches shed light on possible lessons for ecological sustainability governance strategies, COVID-19 has simultaneously demonstrated the importance of local resilience strategies and exposed the fault-lines of the current global system.

In response to this, we explore four COVID-19-related lessons for advancing socioecological resilience in a time of systemic shock: (1) the potential of prefigurative politics; (2) the extent to which ontologies can underpin systemic change; (3) the value of questioning dominant regimes, such as existing models of healthcare organization; and (4) the importance of cooperation and prosocial behaviors. Given that prevailing environmental strategies have proven insufficient, we use tools from the systemic transformation literature to call for novel socioecological strategies that strengthen cooperative prefigurative political actors and groups to act as attractors for socioecological change.

2. Complex Systems, Socioecological Resilience, and the COVID-19 Shock

Since the industrial revolution, growth has dominated the global economy and has become a core driver of human behavior [2,3]. As the global commitment to growth strengthened, so too did the intimate link between growth and medical technology, innovations, and taken for granted approaches to medicine and public health. Health institutions are all now enmeshed in a complex system that is global in scale and scope. While once much more personal, conversations around health now involve national governments, corporations, regional trading blocs, and supranational institutions such as the Organisation for Economic Co-operation and Development (OECD), the United Nations (UN), and the World Health Organization (WHO).

Socioecological systems have never been more tightly coupled. This interdependence increases the risk of global-scale, systemic failures that spread rapidly, not only across geographies but through seemingly disparate domains of social and economic life [4]. Most difficult of all is the extent to which unsustainable patterns of global economic growth have become prerequisites for solving medical and health problems through, for instance, global supply chains, investments in research and development for new vaccines and pharmaceuticals, incentives for technological innovation, and profit-centric healthcare delivery models. The COVID-19 pandemic underlines the extent to which problems of medicine and health are now also financial, economic, ecological, and even geopolitical and military problems.

Such dependence on economic growth makes it difficult to reconcile the ecological integrity of global life support systems with the continuing trajectory of health improvement and a growing capacity for medical intervention. Growth has, on the one hand, led to incredible advances, while on the other hand, it has generated diseases of affluence, including respiratory disease from air pollution; traffic accidents; problems of mental health and suicide; and the emergence of new vectors and pathogens from the disturbance of previously separate ecosystems. All of these are central concerns for the planetary health movement [5,6].

For decades, academics working in the interdisciplinary domain of complex systems have highlighted the paradoxes of global connectivity [1,4]. Globalization has most certainly mobilized the power of free markets to generate unparalleled wealth, lifting hundreds of millions of people out of absolute poverty [7]. Vaccination programmes, house building, transport systems, the provision of clean water, and public health systems have expanded in many areas of the developing world, not least China and India, where the burgeoning middle classes are now greater than the population of Europe. But the same process has ratcheted up the ecological burden on the biosphere, not just in terms of climate change but also pollution, crashing biodiversity, the destruction of habitat, and the creation of unpredictable novel ecosystems—not least the evolutionary species-jumping viral outbreaks associated with Ebola and now COVID-19 [5,6].

Since the 2008 global financial crisis, it has become clear the extent to which globalization has created systemic risk in relation to financial systems [1,4]. The globalization of production has seen nation-states become ever more interdependent, with national

economic growth tied to an infinitely complex web of supply chains, linked by automated "just in time" stock flow and production management systems. Whether in the production of ICU ventilators, masks, and other PPE or the innovation and production of vaccines and related pharmaceuticals, the COVID-19 crisis has underlined not just the benefits of cooperation but also the dangers of external dependence. The early months of the COVID-19 pandemic revealed fragile supply chains and inadequate national preparations. It also saw the undermining of international cooperation and institutions, failures of solidarity, and the re-assertion of civic nationalist interests, as what can only be described as panic gripped the policymakers of many key nations.

In these ways, the pandemic and the resulting economic crisis have exposed fault-lines in the global system whereby the trajectory of medical and health systems will emerge as a function of:

1. Ecological limits to growth: On a finite planet, there are biophysical limits to complexity and growth. All health innovations and systems—whether investments in clean water or an HIV vaccine—come with a biophysical cost and proceed at the expense of "ecological space" elsewhere in the system [8].
2. Ecological limits to societal connectivity: Tackling problems of culture, justice, health, and social change in relation to health presents new challenges. Societal connectivity both creates the conditions for cherished gains in social justice and wellbeing and at the same time exacerbates risks associated with tightly coupled socioecological systems.
3. Geopolitical constraints regarding trade relations: Peak globalization and an emerging consensus that the West's relationship with international partners has become very dependent may see a systemic shift away from outsourcing labor intensive manufacturing to East Asia and the re-emergence of more capital-intensive production within Western economies.
4. Reimagining the importance of "care": We are increasingly faced with a tradeoff between capital intensive medical technologies that depend on growth, and improvements in public health that involve the reordering of social relationships and institutions, including more localized solutions.

The ways in which these trajectories interact to shape future health systems also affect the ongoing negotiation of "wicked dilemmas" related to global connectivity. Complexity science demonstrates that tightly interconnected and more homogeneous networks are highly vulnerable to "synchronous failures" [4]. Globalization enhances both of these risks by enabling the rapid flow of materials, energy, people, pathogens, and information across the planet, while simultaneously homogenizing and reducing the diversity of cultures, institutions, values, local knowledge, and problem-solving approaches. Tightly coupled socioecological systems also become vulnerable to critical transitions or tipping events that push systems from one stable equilibrium to another. This characteristic implies that even small perturbations, or minor crises, in a configuration that is close to a threshold, can push the entire system into a period of chaos, after which it settles into an alternative stable state. Those monitoring escalating global risks from a systems perspective have long warned that pandemics, global financial crashes, and various ecological damages, including crossing planetary boundaries, resource depletion, and climate change, could lead to such tipping points [1,4]. Transitions within complex socioecological systems are highly unpredictable, nearly impossible to manage or control, and prone to generating unexpected and even "counterintuitive" results [9]. With these insights into the dynamics of complex systems as a backdrop, COVID-19 enters the landscape as a "perfect storm" at the intersection of ecological and epidemiological change, and financial and geopolitical instability.

3. Prefigurative Politics and Resilience

By drawing on strong prefigurative politics, some local communities, or entire countries, have responded to the pandemic with greater certainty and ease in decision-making. While we have yet to see what constitutes an effective response to the pandemic in a more long-term view, prefigurative politics have played a role in decision-making. This dynamic, and other movements throughout history, demonstrate the power of prefigurative politics for responding to a crisis. Limits to growth are eroding the walls between the existing socioecological regime and social change defined by widespread social, economic, and political collapse. This dynamic can already be observed in the negative health effects of crossing planetary boundaries, which range from accelerating the spread of vector-borne diseases to elevated rates of cancer, loss of food security, and mental distress [5,10].

Prefigurative politics encompasses strategies through which social movements embody the ontologies and societies which they envision [11]. It is the political practice "of those forms of social relations, decision-making, culture, and human experience that are the ultimate goal" of the social movement [12]. Prefigurative approaches to social change privilege means over ends, believing that the outcomes of a social movement will be determined by the ways in which it pursues its goals. In a Weberian sense, prefigurative politics is "value-rational", or grounded in collective values. It does not necessarily seek change using the mechanisms of the existing system (e.g., multilateral agreements, government policy change), but finds spaces within the current system to establish new modes of being in the world [11].

Prefigurative politics is a path to new patterns of social relations that can be imagined from within the current system. These diverge too much from the mainstream to gain widespread traction under existing conditions [13,14]. Prefigurative approaches are occupied by efforts to avoid unintentionally reproducing existing power and authority structures, values, and ways of relating. As a result, they tend to be radically democratic, community-centric, and counter-hegemonic [12–15]. Many social movements in the 20th and 21st centuries, such as those for peace, women's rights, the environment, anti-capitalism, and Indigenous rights, have included prefigurative elements [11,14]. The success of a prefigurative experiment can potentially be determined by the extent to which the prefigurative structures and ways of being attract participants, enter the mainstream, or displace dominant institutions and value systems [11].

Theories of prefigurative politics arise from opposition to disruptive forces in early 20th-century Europe, including industrialization and bureaucratization [11]. "Between 1918 and 1920, Gramsci developed a theory of socialist transformation that identified factory councils in Italy as key elements of a radical political order that would take hold in the spaces opening up as a result of the escalating crisis in bourgeois society" [12,16]. This conceptualization of the potential of prefigurative experiments to gain ground as crises accumulate in the dominant regime is now embedded within theories of socioecological system transformation in resilience studies and social innovation [17,18].

COVID-19 has certainly demonstrated the failure of hyperpolarized political systems (e.g., the USA, England, and Brazil). In such nations, societal consensus on what constitutes an appropriate response to the pandemic has failed, and measures seen in other countries as reasonable and proportionate have become weaponized and totemic, leading to cascading failures to control the impact of COVID-19. In the USA and the UK, allegedly strong institutional capabilities to respond to a pandemic have been swept away by polarized arguments and poor political decision-making. The paradoxes that COVID-19 has exposed in right libertarianism, as displayed especially in the US and Brazil, have been among the most baffling features of the pandemic—a refusal to accept any limitations on personal freedom (such as mask-wearing) even when this will harm others, yet a failure to grasp that choosing such actions directly implies that others need feel no obligation to protect these very freedoms, precisely because their safety was of no concern to the libertarians.

Successful political responses to COVID-19 have by no means mirrored the prefigurative tropes of democratic/anarcho-/libertarian socialism which have traditionally been associated with "prefigurative politics" as a term. Acceptance of, submission to, and trust in democratically accountable state authority and enforcement has been an essential ingredient of COVID-19 success in those democratic nations which have fared better to date. Unquestionably, notions of civic–national solidarity have been at the fore in those nations or regions which have mounted successful responses; in some cases, such as in Australia, these have resurfaced with surprising vigor, against the grain of both conventional neoliberal politics and leftist internationalism.

It is significant that, where it has been achieved, effective control of COVID-19 transmission has been secured overwhelmingly by the use of social, rather than medical, interventions: social distancing, contact tracing, quarantine, hand hygiene, and face masks. While enhanced by modern pathology testing techniques and digital technologies, these tools would have been instantly recognizable to our forebears combatting Spanish Flu one hundred years ago. Social interventions and technologies may similarly hold greater promise than medical technologies in fighting non-communicable diseases in the future; it is uncontroversial to suggest that action to tackle the social determinants of health and the "consumptagenic environment" [19] are likely to yield greater gains in population and individual health than increased spending on healthcare.

4. Systemic Change and the Importance of Alternative Ontologies

Proponents of "degrowth" [20] view the crisis as a vehicle to leverage wider change that could see our carbon footprints fall as we buttress public health and life-course approaches to care. Health professionals concerned about the effects of climate change hope that the pandemic will make it possible to address, simultaneously, both global health and ecological challenges [21,22]. The "COVID-19 shock" could tip the system towards a more resilient future. Certainly, there is the danger of further corporate consolidation, surveillance, and atavistic forms of renationalization. But there is also the significant potential for relocalization, the re-embedding of markets, a slowing down of cross-border capital and labor flows, and more "viscous" forms of economic life, with trade and cultural barriers insulating local and particular configurations of economy and culture [23].

On both the left [24,25] and the right [26,27], visions of relocalization have always centered on the "re-embedding" of markets, the centrality of face-to-face relationships rooted in both extended family and community, and, often, an insistence, albeit unspecified, on the need for some kind of "re-enchantment". On the ecological left, the theme of re-enchantment can take the form of a spiritual reconnection with nature and an ontology of relationality as, e.g., in developments in contemporary Paganism and radical environmentalism in other new religious movements and ecospirituality [28,29]; but on the right, it appears more often in the rearticulation of traditional religion [26,30]. What they share is a commitment to the intersections of place, landscape, family, and spirituality. This is clearly echoed in the planetary health movement's recognition of the importance of religion, spirituality, and Indigenous knowledge [31].

In the history of capitalism, there has been a constant tension between the integrity of context-bound places, landscapes, and ecologies on the one hand, and the corrosive impact of both science and markets, on the other. Market pricing construes any "thing" or process as commensurable with any other. Science (and medicine) are likewise predicated on a single model that can describe and compare every phenomenon with any other. Together with monotheistic globalising religions, science and markets embody a universalizing imperative that is intrinsically corrosive of local ways of knowing, and cultural particularity. But they have also combined to create and make sacrosanct the understanding of the individual that is implicit within the concept of human rights and the taken for granted shibboleths of liberal societies [32,33].

In the domains of medicine and health, as with economics, ecology, or politics, a stable accommodation between local and global is difficult to achieve. The minimum requirement for enabling localism to thrive, alongside any significant degree of global connectivity, is some re-embedding of markets and the recreation of more barriers between protected domains ("small pools") of economic activity. The intuition of planetary and public health advocates is often that such a relocalization also is a prerequisite for less medicalized, less individually focused, and more societal approaches to wellbeing.

With myriad local examples arising amid restrictions on travel and global trade, it is at least conceivable that the COVID-19 pandemic could act as a driver of a more structural process of re-embedding. All over the world, companies are retooling to support the production of personal protective equipment (PPE). During a comparable crisis in World War II, many merchants and retailers lost both customers and markets, saw key employees drafted, and experienced disrupted supply chains. This led to extraordinary transformations across various sectors: the repurposing of production lines; the entry of women into the workforce; and technical reorganization and productivity gains. In this way, shocks to the system can function to expose weaknesses and opportunities. Though rare, such episodes provide a glimpse into alternative economic regimes—configurations that, although presently unrealized, exist as a latent potential in the landscape of possibility that complexity theorists refer to as the "adjacent possible" [34]. Thus, for instance, war-time re-organization prefigured the Keynesian mixed economy and welfare system that emerged postwar. To what extent do current transformations similarly augur more permanent changes to health systems and their relationships to the wider economy? There certainly seems to be a growing consensus that future systems should favour rapidity of response and relative insulation from more risky geopolitical relationships.

In the emerging landscape, there is a real paradox for established political actors. Drivers and "solution sets" cut across the conventional left–right axis. In particular, there is a mutually unacknowledged convergence in relation to a more localist "prosocial" trajectory between those left-minded greens focused on health and ecology, and communitarian/national conservatives focused on family and protectionism. For instance, tariffs and a collapse in low-cost Chinese production could be a massive boon to high tech, "4th industrial revolution", backyard "additive manufacturers" and fabricators. The global economy is currently driven by a model of cheap, high-volume, disposable consumption, globally dispersed but functionally integrated, and maximally extended, "just on time" supply chains. A more localized economy could tilt significantly toward economies of scope and bespoke, high-cost, high-quality, repairable, craft production [25]. Although the Biden victory in America is likely to see the reassertion, at least at the level of policy, of the predominantly globalist division of labor between less expensive international production and consumption in the West, it seems unlikely that this Bush–Clinton-era political economy will survive the coming depression without serious modification.

5. Dominant Regimes under Question

While the scale of the economic impact of COVID-19 appears to have come as a surprise to policymakers, it is consistent with emerging evidence that the world is transitioning into a "postgrowth" era, as global economic growth rates have slowed over a period of decades. This relentless slowing of growth has been driven by structural economic factors such as inequality and indebtedness; the demographics of aging populations; encroaching ecological feedbacks and limits; and by damage from major shocks (financial, environmental, and now a pandemic) whose frequency appears to be increasing [35]. This backdrop of "limits to growth" will become increasingly visible as the central constraint upon healthcare systems in the years ahead [36]. COVID-19 has given high-income health systems a rather shocking reminder that material resources may not always be available. Resource constraints will be felt more, rather than less, keenly in many health systems in the future. Healthcare and medicine will be challenged to transition away from a deeply held

cultural belief that "more is better" towards a new culture of sufficiency in technological interventions.

Significant change is already happening. Doctors on the front lines have implemented new ways of working that are more collaborative, less bureaucratic, and, incidentally, greener [37,38]. National governments have begun to explore basic income policies to help citizens cope with massive unemployment [39,40]. (It is worth noting that this policy has even been vaunted by Stephen Bannon as the centrepiece for a post-COVID "national populist" political economy [41].) At lower scales, neighbors are self-organizing to ensure that those most vulnerable to transmission have their basic needs met [42]. Access to online and telehealth mental health services has expanded and the mental health risks of social isolation are a recurring target for commentary and intervention.

COVID-19 provides important lessons for the necessary evolution of health systems to meet the challenges of the Anthropocene. Central among these is the extent to which global health systems are implicated in a series of wicked dilemmas related to global connectivity and economic growth that must be negotiated to build resilience to future crises. Healthcare must become more localized, less complex, and more antifragile—becoming stronger in adversity, rather than bemoaning the passing of some golden age. Yet the global nature of medical and scientific knowledge will remain, and that knowledge must be shared rapidly and widely across all nations without hindrance. Hopefully, the particular horrors of overwhelmed health systems will not become a "new normal"; but a certain toughness of mind and a greater recognition of the limits of medicine may prove to be a useful legacy of this pandemic. Humanity has only ever succeeded in eradicating one disease, 40 years ago [43]. Even as the world celebrated that achievement, HIV/AIDS was already on the move: we still have no vaccine for HIV to this day. And efforts to fully eradicate polio, the second target pathogen, have stalled. COVID-19 reminds us that we would be wise to replace hubris with humility as we seek to safeguard the health of both humans and our planet.

The exposure of crucial healthcare supply chain vulnerabilities was one of the earliest lessons of the COVID-19 crisis, and this may yet be one of its most enduring legacies. Liberal political preferences now come to be in tension with significant drivers for localization that might conceivably accomplish, even if incidentally, multiple sustainability goals, particularly around shortening supply chains and instantiating more place-bound configurations of economic and social life.

The pandemic is proving particularly disruptive with respect to the spatial arrangements of service sector office work and higher education. Forced to move curricula online, universities have responded with admirable speed and flexibility. However, the success of this transition has brought to the fore real questions about the traditional campus model of education. Grade inflation [44], the overproduction of both undergraduates and PhDs [45,46], and a proliferation of soft disciplines with questions regarding academic merit [47,48], all tied to a culture of credentialism, became a persistent focus for critique long before the current crisis. But against the backdrop of a massive economic contraction, the pandemic raises difficult questions about the sustainability of overextended campus infrastructures and the number of institutions. At the same time, student experience shows not only the extent to which much of the current offering can by replaced by online provision, but simultaneously underlines the value of premium, face-to-face interactions, in small groups, with highly intelligent and motivated peers. This seems to point towards a contraction of the sector, and a bifurcation between more extensive online programming and expensive, high-value-added traditional models.

Similar considerations are wreaking havoc in city centers as large companies close in-person operations and move online. The very success of this transition raises real questions about the need for expensive, downtown office infrastructure [49]. Some employees have welcomed this move; others have found it psychologically challenging. Since a "return to normal" seems unlikely [50], the pandemic will likely be seen as a turning point not just in the organization of clerical and office work, but also family life and—in the

long term—the structure of urban settlement [51]. Coinciding with widespread urban unrest, protest, and rioting, the abandonment of the office has accelerated wider processes of middle-class and white flight [52,53]. Such developments are likely to accentuate the existing polarization between the winners and losers of globalization and between those who, by necessity and volition, remain more attached to particular, place-bound communities (people Goodhart [54] refers to as the "somewheres") and more highly educated, mobile, and cosmopolitan individuals who are increasingly detached from such places (the "anywheres" – or, as Toby Young [55] renders it, the 'nowheres').

6. Cooperation and Prosocial Behaviors

The COVID-19 crisis exemplifies the kinds of unprecedented and unpredictable change that we are likely to see as we move forward into turbulent futures. Dealing with such uncertainty is best done through cooperation and prosocial behaviors. Individualism is a product of industrialization, not an inherent trait of humanity. Historically, cultures that have engendered group cooperation outcompeted other groups [56]. Mainstream environmentalism has been predicated on incremental change achieved through parliamentary reform, itself linked to the gradually changing behavior and value orientations of rational individual citizens. In appealing to rational and sovereign individuals, the cognitivist bias of mainstream environmentalists has engendered a default preoccupation with material or financial incentives and/or education. This commitment to ontological and moral individualism conflicts with complex systems' perspectives on socioecological change that emphasize nonlinearity, ongoing cycles of growth and creative destruction, and cross-scale dynamics. But it also underplays the significance of unconscious motivations and substantive rationality evident in social psychology, cognitive science, and the anthropology of religion.

The inertia and self-righting dynamics of capitalist political economy are indicative of a deeply resilient system. This regime centers on the relationship between market and state processes, a dynamic that has defined the dominant left/right spectrum through which party politics is ordered. This ostensibly agonistic left/right dynamic obscures the fact that both market and state are predicated on a society of individuals and the absolute dependence of individuals on market- or state-based institutions for economic, welfare, and physical security—and the elimination of mutualist, community-, place-, and family-based "survival groupings". An alternative modernity would see some re-emergence of the latter in the context of "livelihood", gift economies, and localization.

Embracing a political economy of renationalization and localization could serve as a tipping point for planetary health. But this process will not be straightforward (see Figure 1, developed during discussions between authors). "Green" liberals and traditionalist conservatives have different (and often conflicting) motivations for pursuing political–economic relocalization [57] and use opposing tactics to accomplish their intended goals (e.g., Green New Deal vs. Nationalism [41]). However, both pathways have the potential to generate common ground for sustainability at local, national, and global scales—for instance, by re-embedding markets within communities or lowering the ecological footprint of material goods by shortening supply chains [58]. It implies disrupting global production chains without weakening global knowledge flows and connectivity. As we consider how the "COVID-19 shock" can be leveraged to provide opportunities for more prosocial forms of production, it will be important to ask:

- How can right and left visions of localism be reconciled?
- What should be the appropriate balance between global economic integration and local sufficiency?
- What do more locally based, public-health-oriented, and less medicalized health systems look like?
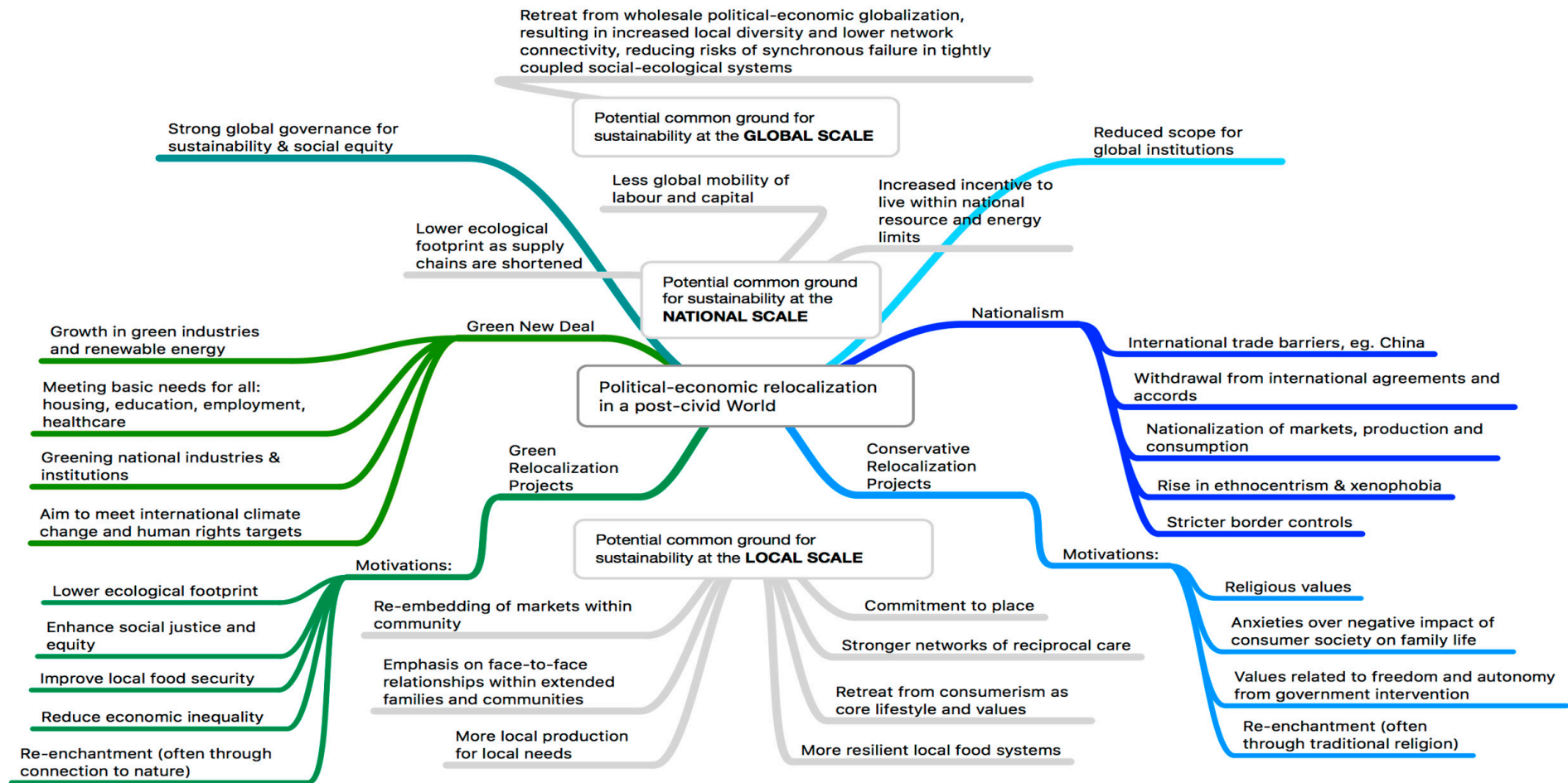- What are the systemic dangers of moving in this direction?

Figure 1. Drivers of relocalization in social and economic systems.

Strengthening these areas of research in relation to system transformation would help to lead to what Törnberg referred to as "internally generated innovative power" [59]. This framework of change sees social evolution and transformation as utilizing, and immensely benefiting from, local diversifications that favor localized visions of a new basin of attraction for a postcapitalist world—similar to what we have seen in the context of COVID-19 success stories.

In the event of a global-scale transition to a new socioecological regime, the most viable alternatives to industrial capitalism are unlikely to be found among the solutions proposed by mainstream green politics. Self-identified environmentalists working for change in the academy, in the new green economy, in government, and in sustainable development NGOs remain largely embedded within a cosmopolitan worldview premised on a global industrial division of labor. Their visions can only be achieved in a growth economy. In the event of a nonlinear change toward a new political economy, these mainstream green solutions will be swept away along with their supporting system, rendered meaningless by the constraints of a newly place-bound life.

6.1. Cooperative and Prosocial Example: Makers during COVID-19

The ontologies and practices with the most potential to take root in an alternative socioecological system may be those embodied by marginal prefigurative groups. For example, varied versions of Makers, people who take the power of production into their own hands, stepped up during the COVID-19 crisis to fill necessary gaps in supply chains, support parents who found themselves locked down at home with small children, and provided free designs for personal protective equipment. Makers did this for free, as a collective, and for no other reason beyond cooperative and prosocial motivations. Their rapid response was empowered by the collective and cooperative nature of the global Maker movement. During COVID-19, Makers exemplified the Stockholm Resilience Center's seven principles for resilience [60]. Makers were able to rapidly adapt to change through a decentralized governance structure that maintained diversity and redundancy. They do so through distributed peer-to-peer networks that are responsive and real-time to help all other nodes continuously learn as new needs and innovations are developed. This open network allows for broad and global participation and use of the ideas without barriers.

Modernity is defined by an enormous increase in per capita access to flows of energy and materials that have been both made possible by and made available a consistent pattern of innovation, new technology, and consumer durables that are synonymous with affluence. Until recently, this trajectory of innovation was inseparable from economies of scale, mass production and consumption, and the expansion of global markets. And for this reason, all new technologies and gadgets were associated with an enormous "complexity overhead"—and were expensive in terms of energy and materials. New micro-fabrication (e.g., 3D printing) and peer-to-peer production and innovation systems, characteristic of Makers and Makerspaces, now make it possible to conceive of uncoupling high technology and innovation from the logic of mass production, global in scale and waste. The critical but unanswered question is the extent to which such systems can reduce the unit energy–material cost of complexity.

While 3D printing started as a novelty, it is increasingly used in the healthcare industry, particularly around innovations in limbs, trachea splints, and brain models for surgical simulation [61]. COVID-19 represents the first widespread and popular usage of 3D printers. Makers and those with 3D printers critically addressed the deficiency in personal protective equipment (PPE) production and supply chains, not only in innovative designs shared widely through open networks, but in local production and distribution of the products. The 3D printing community raised both spontaneous and coordinated efforts to help to reduce various shortages for frontline workers, including testing kits, face shields, face masks, and ventilators. For future needs of on-demand materials and devices, the peer-to-peer (P2P) community of makers is "a resilient advanced manufacturing network enabled by distribution of 3D-printing factories" that has great potential [62]. Through its

"digital diversity and quick prototyping", 3D printing has been "demonstrated to be able to adapt to COVID-19 crisis requirements" [63]. This is important as rapid and effective response to crisis signals resilience for future disturbances. Moreover, 3D printing and P2P networks are able to rapidly respond to the unknown.

Maker communities ask for nothing besides continued collective development of commons and communal knowledge creation. As a collective, Makers are finding ways to bring local production together with enhanced community orientation and resistance toward mass consumption. Modern making is backed by a rich history, beginning with movements against industrialization [64]. Ruskin saw the unfolding of the sustainability crisis through conspicuous consumption. Mass-produced items had lost the beauty and spirit of artisanal ones. He wanted to see the return of handcrafted goods.

William Morris brought Ruskin's ideals to a general level. He argued for social and economic reform via labor reform and bringing art back into society. He argued for simplicity and the return of nature in production and that we should have "nothing in [our] houses that you do not know to be useful or believe to be beautiful" [65].

Now, with over 135 million adult Makers in the US alone, 400 Maker Faires organized globally in 2015, and nearly 2000 Makerspaces worldwide [66], maker communities show a thriving new future of production beyond 3D printing. Making has demonstrated a variety of social benefits [67]. In a survey with over 3500 knitters, Corkhill found that crafters were "very happy" after knitting. Many had started to knit to alleviate stress, and those who took to the craft more frequently indicated higher levels of mental and emotional relief [68]. Another study explored crafters 27–57 years old and found that crafting significantly reduces stress [69].

These studies indicate that Makers as a prefigurative group contribute to wellbeing and quality of life. The effects of craft on the brain are like meditation or yoga, similar to Csikszentmihalyi's concept of flow, which is a state of concentration and total absorption with an activity or situation, to the point where nothing else matters [70]. This feeling of "flow" can help to regulate strong emotions. This means that making can help people who suffer from anxiety or depression to deal with their feelings and cognitive crossfires. It can also combat mental diseases associated with aging, reducing the chances of developing cognitive impairment by 30–50% [71].

As a prefigurative group, they also directly challenge individualized property rights and ownership schemes on which mainstream economics sits. Rather, they celebrate co-ownership and co-production of both social goods and spaces [72]. Everyone's commitment to the network is simply for the wellbeing of all, rather than the development and success of a centralized node [73]. These P2P maker networks are a prefigurative sociotechnical infrastructure that demonstrated resilience and effectiveness when the moment presented itself. This is followed by an increase in interest, further strengthening the prefigurative politic, so it will respond even better next time, and perhaps take on a more central role. While 3D printing may seem innocuous to some, the 3D P2P maker networks are a new postcapitalist mode of governance [74]. This new model encourages both a global and local civic participation that Bauwens calls a "pluralistic commonwealth", in which value creation is both shared and contextually dependent. These distributed producers have long prioritized the democratization of knowledge and open-source property rights—two important elements in a resilient postgrowth economy. COVID-19 gave the P2P production community a chance to demonstrate its cooperative and democratic civil organization to empower new modes of knowledge and property rights.

This vision of high-tech "Maker commoning" is highly disruptive of the habitual left–right political spectrum—or specifically the liberal order that straddles this spectrum. Thus, it presents a serious challenge to both neoliberal/neoconservative right-wing politics (*market liberalism*) and the internationalist, cosmopolitan, and global solidarity of the left (*social liberalism*). The potential of the domain of informal, embedded "livelihood" economies as balance to the market–state resonates with both radical green political economy in the tradition of EF Schumacher, localist conservatism, and social catholic distributism [23,26,75,76].

6.2. Tradeoffs and Uncertainy in Complex Systems

Large-scale transition is inherently unpredictable, and its consequences are inevitably uncertain. For instance, ten thousand years ago, at the beginning of the agricultural revolution, populations expanded, social complexity rose rapidly, and there was a flurry of technological innovation. At the same time, nutrition declined, inequality set in, and devastating epidemics swept through densely populated settlements.

With the transition to modernity, life spans increased, infant and maternal mortality fell, and scientific knowledge deepened. Individuals were, for the first time in history, liberated (at least somewhat) from the circumstances of their birth, unprecedented economic growth and technological innovation improved quality of life for billions around the world, and the horizon of moral consideration expanded, sparking movements for greater equity and social justice. Yet in the midst of what was broadly perceived to be "progress", the expansion of the market economy eroded community ties, individualization obscured the systemic causes of social problems, inequality became global in scope, and an epidemic of chronic disease and mental health problems gripped even the most affluent populations [77,78]. Perhaps most troubling, so much environmental destruction has been wrought since the industrial revolution that we have now crossed ecological planetary boundaries into new socioecological territory, where the future of human civilization is profoundly threatened [79,80]. All the gains made in health outcomes and quality of life in modern societies hang in the balance, and human survival on an anthropogenically altered planet has become an open question [81].

The tradeoffs entailed in previous transitions raise the question of what changes a radical shift to something such as localism will bring. Here, we tread nervously because twentieth century attempts to carve out a "third way" did not go well. One reason for these failures was the propensity of the left to construe the problem as one-dimensional and "solvable". The Enlightenment has always saddled progressive thinking with an intense rationalism, i.e., the assumption that if a sufficiently good model of the problem is understood well enough by the leading actors, it could be solved totally and finally. The elitist implications of this kind of thinking are obvious. But moreover, as Marx [82] and later Schumpeter [83] understood very well, a defining feature of modernity is the ceaseless internal propensity for change ("all that is solid melts to air"). Schumpeter's highlighting of "creative destruction" carried over into modern complexity science and specifically Buzz Holling's "adaptive cycle" heuristic [84]. From the perspective of complexity science, a transition toward a prefigurative politics is often problematic because it embodies a series of paradoxes and dilemmas. Kaitlin Kish and Stephen Quilley [23] identify the following tensions:

1. Steady states are always provisional and temporary: Any ecological or socioeconomic equilibrium produced by an evolutionary, path-dependent process is likely to be dynamic and generative of endogenous processes of transformation.
2. What is good for the system is not necessarily good for individuals or groups within that system: Wholesale system change involving "creative destruction" necessarily involves bad and even catastrophic outcomes for individuals. We are comfortable with this when talking about forest fires or fisheries, but less so when those involved are human.
3. Alternative pathways embody very difficult tradeoffs involving cherished values and priorities: Possible or conceivable political and socioeconomic configurations exist on a "landscape" that defines the relationship between different parameters and phenomena. Any particular configuration cannot occupy different positions in such a landscape simultaneously.
4. Viable alternatives may not be visible: What is perceived as "possible" or viable depends greatly on discourse (the hegemonic "common sense") but also on the vantage point of the present state of affairs. Large areas of the landscape of the "adjacent possible" may not be visible.

The consistent driving force of capitalist modernization has been the commodification and privatization of the commons, the steadily increasing scale and scope of price-setting markets, and the disembedding of the "economy" as a visibly separate sphere with its own logic. A recurring phenomenon in this privatization of the commons has been the elimination of gift economies and the curtailment of reciprocal modes of integration. What Marx referred to as "commodification" means taking needs that were previously met freely through reciprocal gift exchange and creating goods or services that can be bought or sold. For example, child-minding by an elder sibling, as an aspect of the gift economy, can become commodified in the form of commercial childcare; informal learning in the home can become commodified as a function of both state (public schools) and market (private schools); water freely available as a common pool resource can be bottled, privatized, and sold; a culture of participatory musical performance in familial or community settings can be displaced by professional performance and merchandise. In each case, whereas the former does not register as an economic transaction, the latter contributes to GDP.

During the COVID-19 crisis, we see these tensions in real time, particularly regarding women. In Canada, the participation rate of women in the unpaid domestic sphere is 93% compared to 76% of fathers [85]. While father participation increased by 25% from 1986 to 2015, mothers still account for just under two thirds of all unpaid domestic work. Full-time working mothers were more likely to have contributed to unpaid childcare than fathers who were unemployed. While great strides toward equality continue, there is still a gender divide within unpaid domestic work. The COVID-19 pandemic is widening this divide, threatening to limit, or even reverse, progress made on gender equality [86]. There are quantifiable unequal effects of the COVID-19 pandemic on female scientists and those with young children and "the impact is most pronounced for female scientists with young dependents" [87]. These effects will have long-term impacts.

From April 2020 to July 2020, Kish and Sanniti [88] collected preliminary data from mothers in Kitchener-Waterloo, Ontario. Semi-structured interviews with 23 mothers in traditional heteronormative nuclear families with two or more children explored the degree to which women find themselves shouldering additional domestic burdens caused by lockdown measures. With this small sample size, the goal is not to answer any specific question but rather expose areas necessary for future research regarding the unintended consequences of economic contraction on mothers. In total, 30% of the women had to leave their job to care for children during school lockdowns. Slightly more than half of this 30% did not see leaving their job as a burden as they had no intention of advancing. The others commented that they had irreversibly damaged their careers. The husbands did not leave their jobs because they were higher paid, the women distrusted them as competent caregivers, or they refused to quit, citing that the obligation to do so is on the woman. In total, 21% of the women worked from home and all said that their productivity suffered. And while nearly all said that they feel as though they are working more than ever, they feel as though they are failing at both career and being a mother. Moreover, 8% of the women were unable to leave their job and instead switched to night shifts (7 p.m.–7 a.m.), then providing childcare and homeschooling during the day.

In total, 47% of the women reported anxiety related to the addition of unpaid care work and 26% started taking antipsychotic, antianxiety, or antidepressant medication since March 2020. Additional complaints centered on loss of personal time, inability to provide healthy food for their children due to lack of energy, resources, and time, and all expressed feelings of loneliness, disconnection, and loss of self related to their new role. These preliminary data suggest that contractions in the economy and movement to more localized livelihoods may put the burden of care work back on women without prefigured intervention strategies. While this preliminary research was conducted in Canada, the French minister for equality, Marlène Schiappa, stated that the pandemic will have long lasting impacts on women in France, and globally—particularly related to domestic abuse [89]. The government of Sweden made similar remarks on issues related to

abuse; this suggests that countries with more generous parental leave may face different kinds of gender-related issues [90].

7. Conclusions

In this paper, we consider the extent to which the COVID-19 pandemic could act as a shock to the dominant socioecological regime, precipitating a transition toward a new systemic equilibrium more conducive to human and planetary health. The pandemic has highlighted the fragilities of the current globalized system, creating political momentum from both liberal greens and traditionalist conservatives toward the relocalization of production for essential goods. The significant role that the Maker community has been able to fill, and the rise of mutual aid networks, demonstrate the potential of prefigurative movements to use the opportunities afforded by the pandemic to proliferate more prosocial behaviors and structures. Yet the pandemic has also made it clear that we can expect significant tradeoffs in a phase shift from high levels of global connectivity toward more localized approaches to resilience. New research into the effects of the pandemic on women and unpaid care work, for instance, shows that the gender equality won through greater participation of women in formal markets is vulnerable in a context of economic contraction. If COVID-19 does contribute to tipping the global socioecological regime in a direction that departs significantly from growth-centric modernity, realizing the potential gains for human and planetary health will depend upon our collective capacity to navigate these wicked dilemmas, none of which are amenable to easy solutions.

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