



Contents lists available at ScienceDirect

Geoforum

journal homepage: [www.elsevier.com/locate/geoforum](http://www.elsevier.com/locate/geoforum)

# The ‘wicked trinity’ of late capitalism: Governing in an era of stagnation, surplus humanity, and environmental breakdown

Ilias Alami<sup>a,\*</sup>, Jack Copley<sup>b</sup>, Alexis Moraitis<sup>c</sup>

<sup>a</sup> Department of Human Geography, Uppsala University, Ekonomikum, Kyrkogårdsgatan 10, 753 13 Uppsala, Sweden

<sup>b</sup> School of Government and International Affairs, Durham University, The Palatine Centre, Stockton Road, DH1 3LE Durham, UK

<sup>c</sup> Department of Politics, Philosophy and Religion, Lancaster University, LA1 4YW Lancaster, UK

## ARTICLE INFO

### Keywords:

Green state  
Capitalist state  
Environmental transition  
Economic stagnation  
Surplus populations  
Solar panels

## ABSTRACT

Scholars within the fields of political ecology, environmental political theory, and international political economy tend to evaluate the prospects of state-led environmental transitions in general terms – enquiring as to the capitalist state’s inherent properties and their environmental implications. Less attention has been paid to how the state’s green capacities are conditioned by contemporary evolutions in the form and pace of capital accumulation. Capitalism’s *directional* pattern of historical development poses unique challenges for green state projects. Its drive to raise labour productivity metabolises nature on a growing scale, while generating conditions of overproduction and rendering a progressively larger portion of the population superfluous to the production process. Thus, the question is not simply whether the state can rise to the challenge of climate change, but rather *how* states are scrambling to govern the intersecting crises of climate catastrophe, economic stagnation, and surplus humanity. This ‘wicked trinity’ compounds the tensions at the heart of the capitalist state, resulting in an increasing inability to perform its role while sustaining its liberal form. This governance trilemma is illustrated by the case of the solar photovoltaic boom, where the spectacular increase in the productivity and scale of solar panel manufacturing have generated oversupply and falling profitability. States have reacted by indefinitely providing subsidies, financing automation technologies that exacerbate labour superfluity, and relocating solar panel manufacturing to places with authoritarian labour regimes. The case of photovoltaics is a microcosm of the general predicament faced by states as they struggle to govern capitalism’s secular developmental tendencies.

## 1. Introduction

‘[G]lobal climate policy ... is probably the only policy field that doesn’t affect the climate’, observes Tadzio Müller (2021), co-founder of the German climate justice movement Ende Gelände. In its hyperbole, this comment points towards a crucial truth: in the more than thirty years since the creation of the United Nations Framework Convention on Climate Change, states have utterly failed to stop the relentless climb of global carbon emissions (Friedlingstein et al., 2021). Nevertheless, across the political spectrum, states are understood to be the key vehicles for averting climate catastrophe: only the state can rise above the noise of civil society to map out a long-term, binding vision for decarbonization. For intergovernmental organizations, the state’s role must be to transform market incentives such that investors and consumers can confidently decarbonize their activities (Copley, 2022). For social democrats and democratic socialists, states are currently beholden to the

interests of fossil capital and to antiquated neoliberal doctrines – they will not take the necessary climate action unless they are pushed (Aronoff et al., 2019). Even on the radical wing of the climate movement, and for advocates of fossil infrastructure sabotage like Andreas Malm, the ultimate goal is to provoke state action (Malm, 2020). As Rübner Hansen (2021) notes, ‘[w]hat is needed, according to Malm, is not the abolition of both capital and the state ... but the abolition of fossil capital by the state’.

A tension exists, then, between the heretofore dismal record of state climate policy and the pervasiveness of state-led visions of decarbonization. This presents an important puzzle for scholars within the fields of political ecology, environmental political theory, and international political economy. Is the capitalist state structurally reliant upon fossil-fuelled accumulation (Altvater, 2007)? Or is the state’s current fossil-dependence merely contingent, such that past climate policy failures do not foreclose the possibility of a true ‘green state’ emerging

\* Corresponding author.

E-mail addresses: [ilias.alami@kultgeog.uu.se](mailto:ilias.alami@kultgeog.uu.se) (I. Alami), [jack.copley@durham.ac.uk](mailto:jack.copley@durham.ac.uk) (J. Copley), [a.moraitis@lancaster.ac.uk](mailto:a.moraitis@lancaster.ac.uk) (A. Moraitis).

<https://doi.org/10.1016/j.geoforum.2023.103691>

Received 23 June 2022; Received in revised form 30 January 2023; Accepted 2 February 2023

0016-7185/© 2023 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

(Eckersley, 2004)? A dynamic body of literature has mapped the space between these two poles – decomposing the state into its constituent branches, ideologies, governance practices, and competing class interests, thus revealing potential openings for environmental movements to wield influence (Paterson, 2016; Newell, 2021; Death, 2016). Such accounts converge around the consensus that the fast-approaching social and economic dislocations of climate change will force a ‘return’ of the state in some fashion (Parenti, 2015). Yet the question of the particular form and class character of the state that will emerge from these transformations remains open (Toscano, 2020).

This literature has tended to evaluate this puzzle in general terms – enquiring as to the capitalist state’s inherent properties and their environmental implications, abstracted from this or that historical conjuncture. Less attention has been paid to how the state’s green capacity is conditioned by a particular set of interconnected secular tendencies that characterize capitalist development, namely environmental degradation, economic stagnation, and the multiplication of surplus populations. These three tendencies are necessarily implied by capitalism’s perpetual drive to raise labour productivity through the substitution of constant capital (means of production) for variable capital (labour power).<sup>1</sup> This article explores precisely the unique challenges that these interlinked crises of ‘late’ capitalist society pose for green state projects. As such, it follows in the footsteps of Mann and Wainwright’s (2018) work on the reconfiguration of sovereignty and (geo) political authority in an era of climate change (Mann and Wainwright, 2018). We concur with Hunter (2021: 184) that ‘[c]atastrophic climate change and ecological degradation raise the stakes for the critique of the capitalist state’. Yet we add that a critique adequate to the task must recognize capitalism as a social system with a *directional* pattern of historical development, leading to a compounding of the tensions at the heart of the capitalist state and to a reconfiguration of the dilemmas it faces regarding decarbonization and environmental transformation.

Framed in this way, the question is not simply whether the state can rise to the challenge of climate change, but rather *how* states are scrambling to govern the intersecting crises of climate catastrophe, economic stagnation, and surplus humanity. Managing any single pole of this trilemma has unpredictable knock-on effects for the management of other poles, rendering the task of state governance fraught and contradictory. Confronted by this ‘wicked trinity’, this article insists, governance tends to increasingly overflow the liberal tradition’s bounds. Permanent extraordinary central bank actions, militarized policing of the poor, and muscular political responses to so-called natural disasters all evidence the growing difficulty the state encounters in performing its role while maintaining its liberal form. We therefore propose to enrich debates on the environmental futures of the capitalist state by drawing upon Marx’s critique of political economy, which is uniquely positioned to identify, in the present, potential future capitalist state transformations.

This governance trilemma is illustrated by the case of the solar photovoltaic (PV) boom. Widely hailed as a successful example of the ability of clever policy-making and market dynamism to together drive decarbonization, solar PV-generated electricity achieved price parity with fossil-fuelled power plants in the 2010s. However, the same forces that powered price reductions in solar PV-generated electricity, namely the spectacular increase in the productivity and scale of solar panel

manufacturing, have generated conditions of oversupply and falling profitability. Faced with the self-defeating logic of this energy boom, states are pressed to search beyond the liberal toolkit to rekindle the solar industry’s dynamism so as to meet decarbonization targets. This includes the indefinite continuation of solar subsidies that violate liberal budgetary orthodoxy, the financing of solar automation technologies that exacerbate labour superfluity, and the redistribution of solar panel manufacturing to states with authoritarian labour regimes. Solar PV is a microcosm of the general predicament faced by states as they struggle to govern capitalism’s secular developmental tendencies.

## 2. ‘Green’ states and the antinomies of state-led transition

A vast body of literature, at the confluence of political ecology, environmental political theory, and international political economy, has emerged on the prospect of state-led environmental transitions. It aims to address the pressing question: can the capitalist state, given its enmeshment with the compulsive logic of capital accumulation, ever be ‘greened’? The starting point of these debates is that states are increasingly experiencing transformations in the face of planetary environmental crises, heralding the emergence of ‘green’ or ‘environmental’ states. The crux of the matter lies in the progressive potential of such state transformations: are they conducive to the reproduction of business-as-usual, or do they signal states increasingly pursuing transitions to less environmentally destructive productive relations?

Paterson (2016) identifies two broad perspectives on these debates. On the one hand, writers like Meadowcroft (2005), Eckersley (2004), and Dryzek et al. (2003) argue that states, under the pressure of social movements and environmental challenges, undergo a process of ecological modernization leading them to develop a new core function of ‘ecological sustainability’. Put differently, the anti-ecological elements of the capitalist state’s practices are regarded as *historically contingent* rather than *structural*, and can therefore be transformed (Paterson, 2016: 5). This is the ‘greening’ of the state. Duit et al. (2016: 11) neatly encapsulate this perspective: ‘Just as the massive expansion of welfare institutions made late twentieth-century states very different creatures from their nineteenth-century predecessors, so the emergence of the environmental state in recent decades signals further shifts in the character of the modern polity.’

On the other hand, a more critical strand argues that the relationship between the state and capital accumulation is structural, which poses major problems for environmental transition. As a result, overcoming the ‘sustainability/accumulation tension’ at the heart of the capitalist state is impossible (Paterson, 2016: 6). Similarly, NeoWeberian accounts contend that the state hits ‘a glass ceiling’ when the socio-environmental transformation conflicts with other state imperatives, such as the provision of social order, external defence, revenue raising, capital accumulation, and democratic legitimation (Hausknost and Hammond 2020; Douglas 2020). Degrowth and post-growth approaches also tend to view the state as an obstacle to environmental transition, although they often paradoxically make political appeal to it (Koch 2020; Buch-Hansen and Carstensen 2021; D’Alisa and Kallis 2020). Ecological Marxists like Davidson (2012: 31) contend that the state’s dependence on growth and accumulation is an ‘insuperable imperative’ acting as a structural barrier to any environmental transition. Pichler et al. (2020) add that liberal democracy, insofar as it is materially rooted in the confinement of decisions on nature and natural resources to the private sphere of production and consumption, constitutes more an obstacle than a means for future social-ecological transformations. States may experience transformations in how they deal with environmental change, but in a manner that facilitates the further (neoliberal) commodification of nature and the ‘legibility’ of nature for capital (Castree, 2008; Robertson and Wainwright, 2013). Newell (2021: 8), borrowing from Gramsci, refers to this process as a form of ‘trasformismo’, whereby ‘politics and policy reinforce a market liberal approach to transitions within capitalism as opposed to more sweeping transformations of it’. Likewise,

<sup>1</sup> In volume one of *Capital* (1976), Marx discusses the rising productivity of social labour chiefly in terms of a) the production of relative surplus value and b) the concentration and centralization of capital and the creation of a surplus population. Yet in Marx’s manuscripts, unpublished in his lifetime, this historical trend towards rising labour productivity is often discussed in relation to the secular tendency for the rate of profit to fall, which we understand to be key to contemporary stagnation (see Clarke, 1994: 177-178). Several scholars have also pointed out that this expansionary dynamic implies the increasing exhaustion of the natural world (Burkett, 1999; Bellamy Foster, 1992).

Brand and Wissen (2021: 30-31) warn about a 'passive revolution' towards 'green capitalism' – a transformation guided by ruling powers in core capitalist societies, involving a 'highly selective' environmental modernization of productive forces 'at the expense of other world regions' that continue to deliver cheap labour and natural resources to the core. Green capitalism's social and environmental costs would thus be externalized spatially (to the peripheries) and socially (mediated through class, gender, and race).

Paterson (2016: 10) charts an alternative position: 'neoliberal responses to climate change are indeed dominated by commodification of nature as a strategy, in particular— but ...these neoliberal responses to climate change do open up space for both a political-economic and a state transformation, as suggested by green state writers.' This is partly because of diverging interests between capital fractions (e.g., fossil capital, billionaire philanthropists and proponents of geoengineering and other eco-modernization projects, renewables energy capitalists, 'green' financiers, etc.) regarding environmental problems, insofar as they are unevenly exposed to environmental risks and have different accumulation and legitimation strategies. Furthermore, 'this differentiation of business interests has been instrumental in enabling these novel initiatives [carbon offset initiatives, environmental regulations, etc.] to emerge and have produced new forms of alliance among state, business, and civil society actors' (Paterson, 2016: 11). This points to the need for more refined understandings of green state transformations and their politics, opening the proverbial 'black box' of the state.

A variety of perspectives have recently aimed to do just that. Craig (2020) analyses conflicts between various agencies and ministries within the state and the extent to which they represent obstacles to a state-led transition. Brand et al. (2011) deploy Poulantzas' notion of the state as a condensation of societal relationships of forces, underlining that different state apparatuses may have different and conflicting relations with growth, fossil fuels, and nature. Eckersley (2021) turns to neoGramscianism to develop a more historicist understanding of green state transformations that overcomes the alleged functionalism of eco-Marxists and critical political economy approaches. This has political stakes too: a keen attention to uneven fields of power relations, the always incompleteness of hegemonic projects, and the concrete circumstances of specific conjunctures, allows for the identification of 'the political opportunities (and dangers) that are presented for ecological transition, including sites within the state and civil society or intermediaries (parties, social networks etc.) that hold the most potential for new transition initiatives' (Eckersley, 2021: 255). Others draw on Foucault. For instance, Death (2016) conceptualises the green state in Africa as an assemblage of environmental rationalities, discourses, and technologies of government. This sheds light on the centrality of resource governance in state formation and on the multiple forms of resistance that shape the governance of natural resources.

This speaks to a related subfield of political geography – the 'political ecologies of the state' – which engages with 'questions of state-making, and state consolidation and power in relation to manifold and contested "natures", including attention to resource management, infrastructures, or changes' (Harris, 2017: 90). Here too the state rarely appears monolithic, coherent, or temporally/spatially stable (Meehan and Molden, 2015: 440; Robbins, 2008). Rather, it is conceived as the effect of everyday concrete practices and spatial arrangements of humans and non-human materiality. A central area of enquiry is the co-production of stateness, objects of government, and the daily activities of state and non-human agents, with a focus on resistance and contestation. As Robertson (2015: 463) notes, this 'has proven very productive for political ecologists who can understand their site as not just at the receiving end of national and global forces, but as also constituting the hegemony that allows national and global power to operate as such'. However, political ecologists 'have historically been reluctant to be explicit about what the state itself is,' which is problematic insofar as the state as a real abstraction (and something more than the sum of its bureaucrats and policymakers) constitutes a formidable material force for

environmental change (Robertson, 2015: 457, 564; Loftus, 2020: 139, 141). This is arguably a serious obstacle to developing a theoretically informed understanding of the antinomies of state-led environmental transition.

Accordingly, a number of political ecologists have turned to Gramsci's writings, with the objective of simultaneously de-fetishizing the state and acknowledging its material force, by conceiving it as an embodiment of contradictory relations, interests, and socio-ecological struggles within the broader context of capital accumulation (Ekers et al. 2009; Bridge 2014; Robertson 2015; Loftus 2020). This is related to recent interest amongst political ecologists in historical materialist theories of the state, notably the work of Jessop (Whitehead et al., 2007; Pichler and Ingalls, 2021) and Holloway (Angel, 2017; Angel and Loftus, 2019). These theories are useful for political ecologists to study (and advocate for) socio-ecological struggles in-and-against the state. Insofar as the state embodies such struggles, the argument is that practices of self-organization from below have the potential to transform it in a green direction. Political ecologists can thus acknowledge the capitalist state's structural limitations while opening space for the possibility of its transformation. This, however, is not without contradictions: as Loftus notes (2020: 144), socio-ecological struggles waged in-and-against the state 'might have the paradoxical result of empowering the very institutions from which forms of [ecological] injustice emerge.'

This article contributes to these debates in the following way. By contrast with ecological modernization approaches, we provide neither a normative outline of a state that would be more institutionally predisposed to furthering ecological sustainability, nor a specification of the circumstances in which such a green state could emerge. Instead, we side with critical accounts that insist that the liberal capitalist state is the political form of a bourgeois society predicated on the expanded reproduction of capital. However, where critical approaches have largely focussed, in abstract-general terms, on the incompatibility of a genuinely ecological state with capitalist growth, we aim to complicate understandings of the antinomies of state-led transition by focusing on concrete contemporary transformations in the form, pace, and direction of capital accumulation. We refer to the multiple crises of 'late' capitalist society, including economic stagnation, growing surplus populations, and environmental destruction – and their implications for state governance.

We submit that these capitalist transformations provide a useful analytical entry point into the capitalist state's political-ecological futures. Indeed, the capitalist state has demonstrated a remarkable ability to transform itself throughout the history of global capitalism, in response to crises, wars, social unrest, and changing patterns of capital accumulation. Developing a fine-grained understanding of the antinomies of state-led transition requires examining the fundamental contradictions at the heart of the capitalist state form, while further scrutinizing how capitalist governance is affected by historically specific transformations in the dynamics of capital accumulation. Simply put, the state's capacity to address environmental change is conditioned by both abstract-general determinations (its form, nature, and class character) and by the concrete historical development and geographical remaking of global capitalism.

This latter puzzle has not received sufficient attention. Political ecologists writing on the state (including from a broadly historical materialist perspective) tend to focus on everyday practices, green discourses, competing hegemonic projects, and socio-ecological struggles in-and-beyond the state – arguably at the expense of studying the *structuring conditions* of these struggles and practices, namely the expanded reproduction capital. To the extent that the dynamics of capital accumulation have been considered in discussions of green state transformations, these have been understood primarily in terms of a shift from a Fordist to a post-Fordist regime of accumulation (in Regulationist fashion, cf. (Paterson, 1996; Brand and Wissen, 2021), and in the context of theories of ecologically unequal exchange, which emphasize unequal material exchange relations (flows of natural

resources, energy, waste, etc.) among countries holding different positions in the world-system (Hornborg, 2012). Little attention is paid to deep-seated capitalist trends such as economic stagnation and the multiplication of surplus populations, which, while at the heart of burgeoning political economy debates on capitalism's future (cf. Schwartz, 2021; Bernards and Soederberg, 2021), have not been brought to bear on scholarly discussions of state-led environmental transitions.

Our argument is therefore that attention to directionality of capital accumulation allows for the further problematization of the state's role in environmental transition.<sup>2</sup> Indeed, the multiple crises of 'late' capitalist society are the *product of the same developmental logic*, leading to a compounding of the tensions at the heart of the capitalist state and to a reconfiguration of the dilemmas it faces regarding environmental transformation. This not only has fundamental implications for the prospect of state-led green projects – it is also a valuable analytical entry point to scrutinize the seeds of future capitalist state transformations in our miserable present.

### 3. Capitalist directionality and liberal anachronism

#### 3.1. Putting out fires

The liberal form of the state does not simply refer to a variety of capitalist governance, such as the 'liberal market economies' identified by the Comparative Capitalisms literature, nor to the ideological disposition of particular governments. Instead, liberalism is a structural dimension of all states in a capitalist society. Capitalism is historically novel in that it takes the bifurcated form of a separate economic and political realm. In the economic arena, formally independent actors with vastly different levels of wealth engage in market exchange with one another. The economy is depoliticized in that 'the social allocation of resources and labour' is not chiefly effected through political direction, juridical coercion, or customary obligation, but by the rationalistic 'mechanisms of commodity exchange' (Wood, 1981: 81). Yet this political content does not disappear. It is instead concentrated in a differentiated political arena, where these same market actors now greet one another as citizens of equal standing before the state – a formally neutral institution that stands above the citizenry, seeking its consent to govern in the general interest, and in turn enjoying a monopoly of violence to secure against external foes and uphold social order and market freedom (Clarke, 1988).

Such a state, divorced from the economy and in turn intervening upon it, is structurally liberal whether or not it adopts a liberal governing style. Indeed, reproducing this political/economic separation – the edifice upon which capitalist society rests – may well require both liberal and illiberal policy measures. Liberalism demands the constitution of a private sphere where individuals can conduct their affairs, pursue their own ends, and dispose of their property independently of the whims of public authority. Yet from the state's perspective the separation of the economic and the political is not a merely moral affair. It is a condition necessary for its own material existence, as it depends on the health of the private sphere for revenues and legitimacy. As such, capitalist imperatives shift the state's priorities away from personal liberty: propping up accumulation might even require individuals to 'sacrifice for the survival or rebounding of the economic whole' (Brown, 2016: 11). For instance, as Landa (2010) shows, many liberals themselves endorsed fascist governing principles that suppressed the individual liberties of working masses when these threatened to undermine the property rights of capitalists. Thus, policies that curtail liberal rights and liberties may be instrumental in sustaining the liberal form of the state and preserving the independence of the economic.

<sup>2</sup> We use the term directionality not in the sense that capitalism is pre-determined, but in the sense that it is characterised by cumulative changes in its determinate historical development.

Yet although the liberal state is formally differentiated from the economic sphere, this does not mean that it is autonomous from *capitalism*, relatively or otherwise, as suggested by Regulationist and Weberian accounts of climate policy. States do not enjoy a privileged vantage point vis-à-vis the tumult of capitalist society that would allow them to construct long-term, coherent frameworks to govern capitalist development. Rather, capitalism is a holistic social system, both political and economic. The state is the 'political form' assumed by capitalist social relations (Bonefeld, 2014). Indeed, while state power undergirds every moment in the circuit of capital, state action also accidentally creates a system of abstract compulsions that in turn dominates states. By inserting the national economy into the world market, policymakers unwittingly subject themselves to the alienated dictates of global competition. Governments must wield the state apparatus to ensure their domestic economy's international competitiveness, or face a range of impersonal sanctions. However, the state cannot simply give in to this nebulous competitive imperative. It must simultaneously maintain a stable domestic social order, which regularly contradicts the requirements of global competition. This is the 'politics of governing alienation' endemic to liberalism: the state's attempt to chart a course between the unending competitive dictates that it itself unconsciously reproduces and the heterogeneous demands of its political constituents (Copley and Moraitis, 2021).

Compelled to navigate this contradiction, liberal state governance is haphazard and reactive – more akin to putting out immediate fires than forging durable patterns of economic development. The record of state climate policy illustrates this well. Attempts to reduce carbon emissions must gel with strategies to maximize national economic competitiveness, so as to generate the revenues required to fund green transformations, while simultaneously satisfying diverse political constituencies that include extractive workers and communities threatened by global warming. The result is a policy mess, riven with inconsistencies and U-turns, that is unable to coherently address any of these concerns. Climate policy's enduring failure is not simply a failure of political will, but rather reflects the foundational contradiction of liberal governance, namely that the state must try to purchase social peace while obeying the world market's competitive imperatives.

#### 3.2. Capitalism's developmental logic

If capitalist states are perennially pulled in opposing directions by the abstract pressures of market competition and the concrete demands of political constituents, they are also tasked with governing a social formation with a definite developmental trajectory. In its quest for expansion, the capitalist economy generates a historical dynamic that tends to secularly decay the conditions of its reproduction. Capitalist development is underpinned by a tendency towards waning economic dynamism, a secularly growing surplus population, and an accelerated degradation of nature. These intersecting trends are unleashed by the same logic of runaway productivity growth that propels the accumulation of capital.

The central regulative principle of the law of value is that commodities must be produced within the average productivity standards of their sectors or fail to realize their value (Marx, 1976: 129). The labour time expended in production by individual producers must be validated as value-bearing in exchange if production is to remain profitable (Bonefeld, 2020). Producers falling behind established productivity standards stand closer to financial ruin. Conversely, the nearer they are to the productivity frontier the larger the surplus of value they can pocket.

This competitive pressure drives average productivity to constantly higher levels and in doing so produces an ever-intensifying tension between what Marx calls the *labour process* and the *valorization process*. Capitalist production is simultaneously a process of 'producing utilities' and 'producing surplus value' (Marx, 1976: 304). Yet as capitalism matures, these two functions of capitalist production become

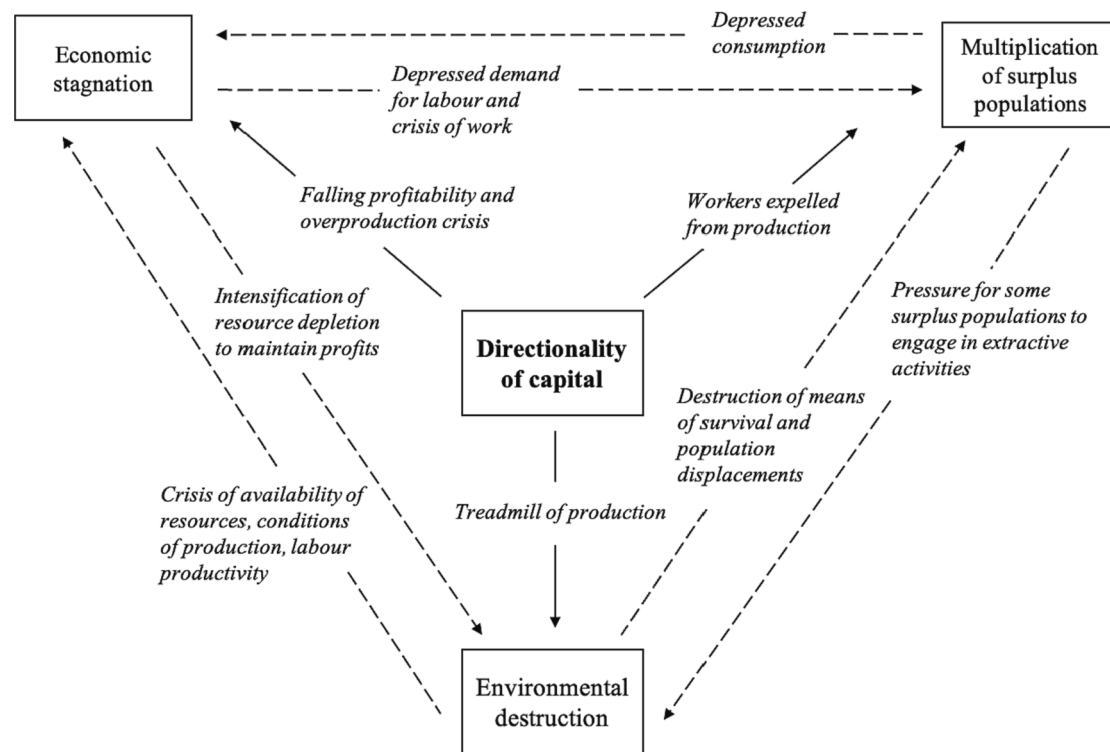


Fig. 1. The 'wicked trinity' of late capitalist governance.

increasingly disconnected because productivity gains expand the amount of 'utilities' produced within a given timespan but decrease their individual value. Consequently, runaway productivity growth tends to undermine valorization by progressively reducing the total *surplus* value represented by a given sum of commodities (Ortlieb, 2013). This fundamental asymmetry between the production of utilities and surplus value is at the source of late capitalism's intersecting crises. Crucially, however, our argument seeks to move beyond the deterministic language of established Marxist accounts of the tendency of the rate of profit to fall according to which capitalism inexorably tends towards a state of lower returns and economic breakdown (see Carchedi and Roberts, 2018). Our account of capitalist directionality points to certain secularly intensifying tendencies – waning dynamism, human superfluity, and environmental destruction – that become increasingly difficult, *yet not impossible*, to counteract or mitigate as capitalism matures.

While individual firms are compelled by the profit-or-perish law of capitalist competition to continuously raise labour productivity, this contributes to conditions of economic stagnation at the aggregate level (Moraitis, 2022). Firms tend to compensate for decreasing profit rates by expanding the volume of production, ultimately leading to market saturation and overcapacities, rendering these firms' viability increasingly precarious (Clarke, 1988). In response, investors may redirect their capital to less saturated sectors. Yet this productivity-enhancing investment risks replicating the same tendency towards overcapacity in a new sector (Endnotes, 2010). In sum, while productivity growth is a structural necessity imposed by the valorization imperative, it simultaneously constitutes the source of capitalism's deteriorating conditions of reproduction. This tendency has been particularly pronounced in recent decades, manifested in the slowdown of GDP growth, weak investment, intensified competition, and industrial overcapacities across sectors (Schwartz, 2021; Benanav, 2020).

Capitalism's in-built tendency towards stagnation amplifies the job-shedding effects of productivity growth. In a dynamic capitalist economy, job losses in a particular sector due to productivity-enhancing technologies can be offset by the acceleration of investment or the development of new products in booming sectors (Marx, 1976: 583).

This becomes increasingly complicated in conditions of stagnation, whereby firms have little incentive to undertake investment (Benanav, 2020). Labourers are expelled from production at a faster rate than they can be re-absorbed. Consequently, exceptionally high levels of investment are needed to recuperate the jobs lost to labour-saving machinery (Marx, 1976: 789). Capitalism exhibits a growing inability to sustain existing levels of labour demand as it matures, thereby generating a trend towards the production of an expanding army of superfluous proletarians (Arzuaga, 2019). Superfluity manifests as both mass unemployment and underemployment, as an increasing number of people are forced to make ends meet in precarious jobs – from app-mediated services to street hawking (Smith, 2020; Jones, 2021; Weiss, 2021).<sup>3</sup>

This crisis of work is inescapably linked to the unfolding environmental catastrophe because runaway productivity growth also generates a 'blind compulsion to dominate nature' (Cassegard, 2021: 194).<sup>4</sup> Schnaiberg's (1980) metaphor of the 'treadmill of production' is a powerful description of the intrinsic link between capitalist production

<sup>3</sup> The overarching trend towards greater overcapacity and labour superfluity does not exclude the possibility that state stimulus on a sufficient scale can result in undercapacities and labour shortages in certain sectors for a period of time. Indeed, the recovery from the Covid-19 recession – powered by extraordinary state interventions – has witnessed industrial supply chains fail to keep up with buoyant demand while many businesses have struggled to find workers (Santacreu and Labelle, 2022). These conditions can be easily interpreted within our framework. On the one hand, they demonstrate that increasingly exceptional measures are needed to generate an uptick in growth and labour demand. On the other hand, current labour shortages are partly the result of people's refusal to return to precisely the type of precarious and taxing jobs generated by an economy characterized by chronic underemployment (i.e., the so-called Great Resignation) (see Choonara et al. 2022; Causa et al. 2022).

<sup>4</sup> Following Marx, we define productivity as the volume of commodities produced per unit of time. Although post-2008 productivity indicators in the developed and developing world have shown signs of a slowdown, they measure the monetary not physical output per worker hence obscuring the growing consumption of nature involved in achieving even modest productivity gains (see Smith 2020: 84-85).

and environmental destruction. The treadmill describes an ecocidal pattern of growth whereby each new round of investment accelerates both the *withdrawal* of resources from nature to fuel production, as well as *additions* to nature in the form of toxic waste or greenhouse gases. While Schnaiberg originally attributed the treadmill to post-World-War-II monopoly capitalism, we argue that this ecocidal growth pattern expresses the deeper tension between the valorization and labour processes. In a context of stagnation, capitalist production must accelerate the extraction of natural resources just to realize the same amount of surplus value as before, since this value is now spread across a large number of commodities (Machado, 2021). Rising material inputs – including energy and raw materials – must be consumed to offset falling profitability. The accelerative dynamic underpinning productivity growth means that capital must consume the material environment at faster rates than natural resources can replenish themselves (Blumenfeld, 2022). Environmental breakdown in turn contributes to the destruction of livelihoods and means of survival, predominantly in the Global South, amplifying other forms of displacement and dispossession and bloating the surplus population's ranks (Bernards and Soederberg, 2021). According to some estimates, 1.2 billion climate-related refugees are expected by 2050 (Transnational Institute, 2021).

For capitalist states, this multifaceted crisis appears in the form of a 'wicked trinity' (see Fig. 1). Each pole of the trinity, albeit a product of the same developmental logic, is experienced by policy-makers as a distinct crisis with its own set of challenges. However, due to the multiple feedback mechanisms between the poles, the contradictions and conflicts associated with each pole cannot be dealt with independently from those associated with other poles. Thus, the dynamics inherent to one pole constrain the state's room for manoeuvre to address the others. This 'wicked trinity' leads to a compounding of the tensions at the heart of the capitalist state, resulting in the latter's increasing inability to perform its role in capitalist society while sustaining its liberal form.

### 3.3. The anachronism of liberal governance

Faced with this 'wicked trinity', states are increasingly called upon to deploy policies that contravene their liberal character. Yet, at the same time, modalities of liberal governance – facilitating market freedom, enabling competition, responsabilizing individuals against economic risks, and depoliticizing economic relations – remain essential to disciplining domestic constituencies in line with the global imperatives of accumulation. It is precisely the growing inadequacy yet continued necessity of liberal governing methods that we seek to capture with the notion of the *anachronism of liberal governance* (Moraitis 2021).

Liberal governance has two faces. Its political face is associated with processes of civic enfranchisement, representation, participation, and equal rights for all (Landa, 2010). Its economic face is concerned with the enforcing of a neat separation between the economic and the political, and the consolidation of a rules-based order to ensure the functioning of 'free' markets (Plant, 2010). Our argument is that the 'wicked trinity' places growing strains on both aspects of the state's liberal character. This is evident in states' contradictory attempts to manage the crises at each pole of the trinity and their interrelations.

Take, for instance, the increasingly coercive forms of rule and repressive technologies of labour containment developed by states in both the Global North and Global South to address the multiplication of surplus populations. Disciplining and governing the latter has involved pronounced authoritarian tendencies, from aggressive border militarization, the development of AI-powered systems of mass surveillance, the criminalization and brutal repression of social movements and various forms of dissent (from the *Gilets Jaunes* insurrection to the climate movement), to the suspension of the rule of law and civil liberties (Bruff and Tansel 2020). Increasingly exclusionary notions of national identity and citizenship have been used to cultivate support from insiders and divide populations.

To be sure, within the liberal order, the promise of political

emancipation has always been reserved for a relatively circumscribed 'community of the free', while those excluded from it – slaves, colonized populations, women, and paupers – have been subject to intense state control (Losurdo, 2011). Yet, in a context of dwindling labour market opportunities and environmental destruction, liberal governance increasingly relies on the exclusion of more and more people from the community of the free. Surplus humanity becomes a matter of policing, surveillance and incarceration (Gilmore, 2007; Clover, 2019; (Wacquant, 2010). Nowhere is this more visible than in the choice of the world's richest countries to spend more annually on securitizing their borders than on mitigating climate change (Transnational Institute, 2021). Consider also the various deals that the EU has made with Turkey, Libya, and Morocco to outsource authoritarian 'migration management,' or the UK's policy to send asylum seekers to Rwanda (euphemistically known as the Migration and Economic Development Partnership). Liberal capitalist states' responses to the multiplication of surplus populations thus appear in the (illiberal) form of a proliferation of police forces, border walls, and restricted – if not denied – civil and political rights, to secure the interests of a rapidly thinning community of the free.

We witness not only the progressive disfiguration of liberal governance's political face, but also the hollowing out of its economic core as policy-makers find themselves pressed to violate the principles of liberal economic policy. Of course, the recourse to emergency policy measures that temporarily suspend or bypass the logic of market mechanisms is not a novel feature of liberal governance. What Best (2017) calls 'liberal exceptionalism' is in fact a recurring policy reflex that capitalist states embrace to manage social tensions in times of crisis, ultimately to preserve the liberal order itself (Mann, 2017; Šumonja, 2021). Yet, in the context of late capitalism's wicked trinity, there is a change in the scale, intensity, and frequency with which governments have recourse to such measures. Put simply, in late capitalism, the line between 'normal' periods of liberal governance and exceptional periods of emergency politics becomes increasingly blurred.

Liberal economic governance has in many ways turned into permanent crisis-management. The bank bailouts and massive liquidity injections following the 2008 crash already offered a glimpse of the scale of exceptional, market-distorting interventions states are called to undertake to maintain the stability of a fragile financial system that has grown on the back of a persistently stagnating economy (Tooze, 2018). The crisis management of the COVID-19 pandemic emulated the same logic of 'emergency Keynesianism' (Šumonja, 2021). To prevent the aggravation of the slump's accompanying social dislocations, governments around the world once again suspended 'market normality' and resorted to extraordinary monetary policy, the nationalization of ailing firms, creation of furlough schemes, and provision of state aids.

Liberal economic governance is transforming in the face of tendencies towards economic stagnation, industrial overcapacity, and intensified competition in global markets. Since the turn of the millennium, states in both the Global North and Global South increasingly rely on muscular forms of statism. They have enlarged their role as owners of capital and as investor-shareholders, resulting in the proliferation and growing salience of state-capital hybrids (such as sovereign funds, policy banks, state enterprises) (Alami and Dixon, 2022, 2023). They experiment with new combinations of techno-industrial policy, encompassing funding for R&D and scientific-technical training, government procurement policies, credit subsidies, tax breaks, targeted state aid packages, national champion policies, investment in large-scale infrastructure, etc. These policies aim to achieve defensive objectives (protecting sectors and restructuring declining industries at home in the face of stagnation and competition) and offensive ones (favouring transitions to new areas of sectoral competitiveness, including in energy renewables, as we will see below) (Bulfone, 2023). These strategies are often combined with aggressive forms of competitive economic nationalism, including trade and investment restrictions and 'beggar-thy-neighbour' measures in the realms of exchange rates and monetary

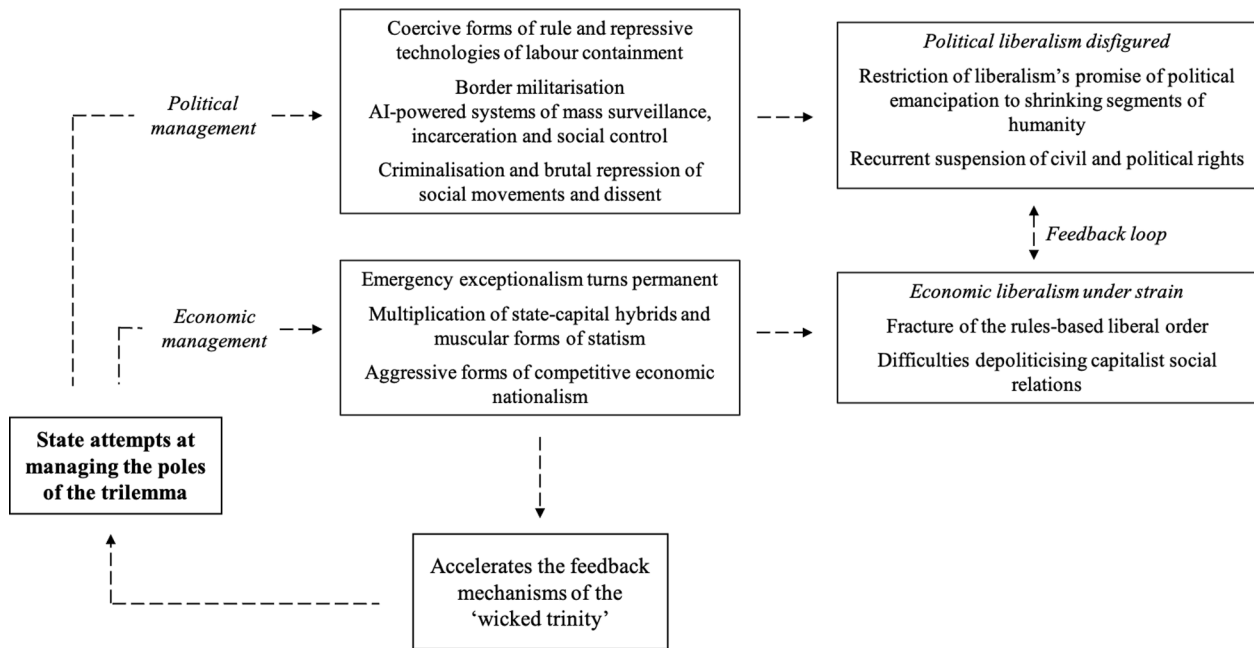


Fig. 2. The anachronism of liberal governance.

policy, to shift the burden of economic adjustment to other states.

These transformations put considerable strain on liberal economic governance. Internationally, they threaten to fracture the rules-based liberal order governing global trade and investment. Domestically, the recurrent suspension of market-liberal principles (such as free competition or individual responsabilization [Davies, 2013]) make it increasingly difficult to legitimize the political-economic dichotomy. Formerly depoliticized economic matters become more exposed to political contestation and struggles as they enter into the ambit of state responsibility. States tend to respond to the latter in the violent and authoritarian ways discussed earlier to maintain order, placing further pressure on the political dimension of liberalism.

Capitalist governance, then, tends to increasingly overflow the liberal tradition's bounds. This tendency is likely to deepen in the future, as climate change intensifies the pressures placed upon the state to violate liberal orthodoxies in order to avoid the disorderly unravelling of liberal society itself. Besides, as they attempt to remedy stagnation states can exacerbate the capitalist economy's tendency towards escalating cycles of labour displacement and environmental disaster. States are thus directly implicated in the feedback mechanisms of the 'wicked trinity' and inadvertently complicit in the anachronism of liberal governing principles.

And yet the paradox is that the growing anachronism of liberal governance does not entail its wholesale abandonment. The frequent bypassing and incoherent application of market principles is often interpreted as a tell-tale sign of neoliberalism's crisis and possibly imminent demise (Kotz, 2015). Yet liberal exceptionalism occurs within limits determined by the capitalist form of the state (Bonefeld, 2010). States may 'loosen market-based constraints' on specific economic sectors (through, for instance, liquidity injections, subsidies, or protectionist measures) as a means of managing crises or achieving specific objectives (such as catalyzing industrial upgrading or energy transitions), but they cannot go as far as dismantling market discipline altogether (Burnham, 2011). Doing so would rupture the social relations that constitute capitalist societies, sabotaging the material basis of the state's own reproduction (de Brunhoff 1978). Market discipline is necessary to ensure that economic actors are compelled by the imperative of world-market competition to produce according to average

productivity standards. Thus, liberal measures remain relevant insofar as they enable states to maintain competitiveness by exposing economic agents to capitalist discipline. Liberal governance is both increasingly anachronistic and insuperable in a society ruled by value.

In sum, in striving to secure the conditions for sustained accumulation, states inadvertently create a world increasingly ungovernable by liberal means (see Fig. 2). In the context of a warming planet, an economy in quasi-permanent deceleration, and a growing surplus population, liberalism's promise of political emancipation is restricted to shrinking segments of humanity, while those shut out from the 'community of the free' are exposed to naked state violence. In the realm of economic management, liberal governing principles are increasingly suspended by emergency state interventions to maintain social order and capital accumulation. This dynamic is visible across a range of contemporary political developments, as discussed above. Yet it is even discernible in one of the supposed success stories of the liberal decarbonization vision, namely the solar PV revolution.

#### 4. Contradictions of the solar miracle

##### 4.1. A sunrise industry

'The future looks bright for solar energy', the World Economic Forum observed in 2020. From 2010 to 2019, nearly US\$1.4 trillion of investment flowed into global solar capacity, propelling a rapid growth in solar-generated electricity and driving down its price by more than 80 %, making it cheaper than fossil fuel alternatives in most parts of the world (Frankfurt School-UNEP Centre/BNEF, 2020: 31; IRENA, 2020: 11). Within the broader solar sector, the standout industry has been solar PV. The case of solar PV casts doubt on certain Marxist claims about the fundamental link between capital accumulation and fossil fuels (Malm, 2016; Altvater, 2007), and instead appears to confirm Ecological Modernization accounts of the malleability of capitalism's energy regime (Mol and Spaargaren, 2000). As Paterson (2021: 401) notes, the solar miracle may suggest that 'the investment and technological dynamics of capitalism mean it can in principle shift to non-fossil energy rapidly'.

Bolstering green state claims, solar PV's price transformation was not

a pure market phenomenon, but instead resulted from targeted political intervention. The German government in 2000 implemented a feed-in-tariff (FIT) scheme to incentivize the growth of solar-generated electricity (Hoppmann et al., 2014). This policy saw the German state effectively guarantee the profitability of small- and large-scale solar developers by awarding them above-market, subsidized prices for their electricity. Similar measures were adopted across Europe, the US, and gradually the Global South. By 2011, ‘50 countries had some form of FIT in place, with more than half of these being in developing countries’ (UNEP, 2012: vi). This resulted in a dramatic expansion of demand for renewable energy during the 2000s.

Developers sought to profit from these policy measures, powering a boom in solar capacity construction and a global restructuring of the solar PV supply chain. While Japan, Germany, and the US had historically dominated solar PV production, Asian economies began to ramp up their capacities in the mid-2000s in response to rising demand (Mulvaney, 2019). Chinese firms in particular captured a growing share of the market. While US manufacturers shifted away from the standard crystalline silicon PV design towards more innovative thin film technologies, Chinese firms sought to simply produce crystalline silicon PV panels at lower costs (Mulvaney, 2019). In doing so, Chinese solar panel manufacturers exploited several advantageous conditions: a cheap and disenfranchised labour force, government support, existing production networks for semiconductors, technological expertise from Chinese nationals trained in Western universities, importation of integrated ‘turnkey’ production lines from Germany, and financing from US capital markets (Mulvaney, 2019; Hart, 2020; Nemet, 2019). Firms like Yingli Green Energy achieved vertical integration across the solar PV supply chain, from the production of polysilicon to the manufacturing of panels, resulting in colossal economies of scale (Hopkins and Li, 2016).

As green industrial policy became more important to the Chinese Communist Party’s agenda during the mid-2000s, greater central state funding was channelled into solar research and development. This allowed Chinese firms to achieve impressive leaps in labour productivity (Sandalow, 2019: 74; Hopkins and Li, 2016). By the 2010s, crystalline silicon solar panel production had become a highly automated, capital-intensive affair, with labour making up just 3–4 % of Chinese firms’ costs according to one study (Platzer, 2015). In 2012, these labour-cost, scale, and productivity advantages made Chinese solar panels 20 % cheaper than their US competitors (Hart, 2020: 10). Consequently, by 2016 Chinese producers made up 51 % of global solar panel manufacturing capacity, compared to just 7 % for Europe and the US combined (Mulvaney, 2019: 28).

For solar farm developers, these price conditions translated into a profit bonanza. Prices for their electricity output were set artificially high by states’ FIT schemes, while the prices of solar panels had been lowered by the aforementioned industrial transformations. The ‘total installed costs for utility-scale [solar] projects’ fell by 79 % from 2010 to 2019 (IRENA, 2020: 27). Investment thus flooded into solar developments, particularly in Europe, the US, and Asia, powering a rapid rise in capacity (REN21, 2017: 66). Against the deterministic predictions of Marxist ecological thought, a set of innovative state policies appeared to have effectively harnessed the dynamism of market competition for the purpose of decarbonization.

#### 4.2. Gathering clouds

However, doubts have begun to emerge over the solar market’s future buoyancy. The threat on the horizon is the spectre of over-production. Though not unique to the sector, ‘the tendency to over-production [that] is equally characteristic of all branches of production’ is exacerbated by certain technical characteristics of utility-scale solar (Clarke, 1994: 283).

Utility-scale solar PV plants – constituted by an interconnected network of solar panels and regulatory systems spanning a large territory – require massive upfront investments in labour and fixed capital.

Yet, once constructed, the functioning of solar farms is a highly mechanized affair, implying very low operating costs (Wiser et al., 2020). Thus, when the project is off the ground, the marginal cost of producing *more* solar electricity is near zero. In competitive conditions, this imparts solar power with an exaggeratedly deflationary dynamic (Lewis, 2020). Enhancing this problem is the fact that solar electricity is ‘non-dispatchable’: plants can only generate and sell electricity when the sun is shining (Sivaram and Kann, 2016). This floods the grid with electricity at peak times of the day, further driving down prices and eroding profits. As more plants are constructed and greater solar capacity comes online, these bursts of super-overproduction and consequent price plunges intensify until a ‘breakeven point is reached, beyond which further investments in solar PV are no longer profitable’ (MIT Energy Initiative, 2015: 124). This phenomenon has been termed the ‘value deflation’ or ‘cannibalization’ effect by renewable energy analysts (Blume-Werry et al., 2021; Prol et al., 2020). The danger is that if state subsidies are withdrawn from this sector, and market prices come to reflect the forces of supply and demand rather than political priorities, the cannibalization effect will undermine the business case for solar capacity additions before decarbonization targets can be reached.<sup>5</sup>

A 2015 MIT study (xii) captures the nature of the dilemma: ‘In competitive wholesale electricity markets, the market value of PV output falls as PV penetration increases. This means PV costs have to keep declining for new PV investments to be economic’. In other words, to maintain solar plant profitability, the costs of developing plants must continue to fall at least as fast as solar electricity prices, in an unending downward spiral: ‘cost-competitiveness for solar is a moving target’ (Sivaram and Kann, 2016: 1). Firms in the upstream parts of the solar supply chain – from polysilicon production to panel manufacturing – must perpetually revolutionize their industrial methods so as to deliver ever cheaper solar panels.

Yet upstream firms are themselves struggling with massive over-capacity, depressed output prices, and low profitability, which impedes further investment and price reductions. China’s entry into this industry, which so boosted the fortunes of solar plant developers, was disastrous for many solar panel producers (Hart, 2020). This injection of competition drove up the industry’s capital intensity, as firms the world over sought to survive by introducing advanced machinery and achieving economies of scale (Powell et al., 2015). The tremendous productivity gains unleashed by these machine investments flooded the market with solar panels and reduced prices, pushing down the rate of profit in these upstream segments (Frankfurt School-UNEP Centre/BNEF, 2020: 71). The result is a ‘high-capex, low margin environment’, in which few firms can survive (Buonassisi et al., 2016). A spike in bankruptcies struck the industry in the early 2010s, concentrated in Europe and the US (WIPO, 2017). But even Chinese firms have struggled to remain afloat in these conditions: ‘The median operating margin for a group of predominantly Chinese large manufacturers’, one study found, ‘fell to an estimated negative 40 percent in 2011’ (Hart, 2020: 11). In line with sinking profitability, global new investment in solar peaked in 2011 before falling in the subsequent two years; global panel production rose precipitously in the late 2000s before slowing in the period 2011–2014; and average panel prices fell steeply from 2007 to 2012 before stabilizing thereafter (BloombergNEF, 2019; IEA PVPS, 2021: 50; Roser and Ortiz-Ospina, 2022).

However, just as solar manufacturing began to stagnate – exacerbated by US and EU tariffs on Chinese panels – it was rescued by the Chinese state, which developed a massive domestic solar PV market from 2013 to 2018 through generous subsidy and support measures

<sup>5</sup> Increased energy storage capacity could mitigate this deflationary dynamic by allowing for the better matching of electricity supply and demand. Yet Bistline (2017: 370) argues that ‘storage is not a panacea for preventing decreasing returns’ to solar investment, as its ability to allow suppliers to arbitrage electricity prices declines as storage deployment increases.



(Dong et al., 2020). This tremendous political support catalysed another wave of investment in all segments of the solar PV value chain. Yet this once again resulted in huge overcapacity, particularly in panel manufacturing, that led the Chinese state in 2018 to announce the accelerated phasing out of its solar subsidies (Dong et al., 2020). It is unclear whether, in the absence of such extraordinary support, panel manufacturers can achieve the continually booming output and panel price reductions required to maintain the profitability of utility-scale solar plants.

Solar PV as a whole resembles a dog chasing its tail with less and less vigour. The entire industry is increasingly warped by a pattern of rising productivity, overcapacity, and depressed profitability. Each segment of the supply chain is implored to achieve ever-greater cost reductions just to sustain existing profit rates. But such cost reductions become harder to achieve as new investment is deterred by glutted markets and narrow margins. This exemplifies the directional logic of capital accumulation discussed earlier. As competition drives up capital intensity and labour productivity, the same magnitude of value becomes spread across a greater number of commodities, creating a tendency towards overproduction and falling profitability. As the productivity frontier advances, ever more radical measures to expand markets and cut costs are needed to simply tread water in profitability terms.

Although exacerbated by utility-scale solar PV's technical characteristics, overproduction is a generic feature of capitalist development. What energy analysts observe as solar's unique 'cannibalization effect' is a particular instance of capitalism's universal drive to auto-cannibalization (Jappe, 2017). Indeed, the last twenty years have witnessed this sector begin to transform into a typical capitalist industry, namely one wracked by overcapacity and depressed profitability (Brenner, 2006). This generates a series of intractable problems for policy-makers, pushing them to the limits of the liberal tradition.

#### 4.3. Liberalism eclipsed?

The case of states' governance of solar PV sheds lights on several (if not all) aspects of the wicked trinity. In seeking to allay the looming climate catastrophe generated by capitalism's expansionist logic, states have provided support to solar PV in an effort to catalyse a green investment wave. While initially successful, the dynamism of the solar PV industry has threatened to wane as a result of the self-defeating character of capitalist accumulation. In order to resuscitate this green boom, states are increasingly pressed to undertake actions that not only erode their liberal foundations but risk exacerbating different poles of the wicked trinity.

State subsidies for the solar industry were intended to be temporary. The argument went that subsidies like FITs would incentivize investment in solar panel manufacturing and electricity generation, propelling competition and technological upgrading. Once solar electricity could compete on price terms with other energy sources, subsidies could be withdrawn and the expansion of solar would continue without state support. Following this logic, European FIT schemes peaked in 2009, before being sharply reduced (Sendstad et al., 2022: 5). In place of FITs, the price of European solar electricity has been increasingly determined by market forces, with electricity sold either through wholesale markets or Power Purchase Agreements (Christophers, 2022).

However, with some exceptions, Europe's solar market has failed to flourish without state support. Instead, European solar capacity additions have tracked subsidy changes, with a slight lag – peaking in 2011 before falling sharply (Sendstad et al., 2022: 4). New solar installations in Europe began to recover from 2017, although by 2020 they had still not reached their 2011 peak (REGlobal, 2021). In the UK, for instance, solar subsidies were slashed in 2015, leading to a collapse in solar investment and the loss of a third of jobs in this sector (PWC, 2016). By contrast, 2020 was a record year for new solar installations in China and the US. Yet according to REN21 – a leading renewable energy think tank and governance group – the Chinese and US solar construction boom

resulted from a dash by developers to take advantage of subsidies before their expected expiration at the end of 2020 (REN21, 2021: 119-122). As REN21's Global Status Report explains: 'In 2020, manufacturers and developers across much of the solar PV industry experienced low margins' (REN21, 2021: 129). This meant that the 'cost-competitiveness' of solar PV was 'insufficient on its own' to perpetuate an investment boom, such that 'Government policies continued to propel most of the global market in 2020' (REN21, 2021: 118). '[W]here the external government stimulus to investment was removed, the investment case once again became marginal', Brett Christophers (2021: 151) notes. As deadlines for meeting climate objectives near, and solar proves unable to boom in the absence of extraordinary public intervention, states will be forced to decide whether to sacrifice their decarbonization goals or their liberal budget stances.

In addition, the EU and the US have faced pressures to adopt increasingly interventionist techno-industrial policies towards their domestic solar PV sectors, chiefly in the form of funding for automation. This changing policy stance has at least two objectives. Firstly, it seeks to reverse the annihilation of European and US solar PV manufacturing capacity by Chinese competition. As of 2020, around 66 % of global solar cell production was located in China, while the US and EU each boasted roughly 1 % of global production (REN21, 2021). Secondly, this strategy looks to lower the costs of solar farm development, in order to boost the profitability of solar projects and thereby accelerate the energy transition.

Within the EU's Horizon 2020 research and innovation programme, which ran from 2014 to 2020, funding was directed to 39 solar energy projects. The largest was the development of an automated solar panel manufacturing facility in Catania, Italy: 'The final goal of the project is ... the setting-up of a 100 MW full-scale automated pilot line' so as to regain 'competitiveness of the EU PV manufacturing industry' (European Commission, 2021). Horizon 2020's successor, Horizon Europe, has also earmarked significant funding for solar manufacturing. The US state too has provided various forms of support for solar manufacturing and project development. As part of President Obama's American Recovery and Reinvestment Act, \$12 billion in loans were authorized to the solar sector between 2009 and 2011 (Mulvaney, 2019: 52). This federal support was largely geared towards thin film PV panel production and consequently had disappointing results once cheap Chinese crystalline silicon panels hit the market (Mulvaney, 2019). Yet the Department of Energy has continued extending funding to various solar projects through its Solar Energy Technologies Office (SETO). One 2021 winner of a SETO funding prize, RE2 Robotics, is developing a mobile robotic arm to assist solar farm construction 'by automating processes that are currently done manually' (resquared.com, 2021). Further, the America COMPETES Act of 2022 has authorized \$3 billion to develop a domestic solar manufacturing supply chain – with the specific goal of clawing back production capacity from China (Pickerele, 2022).

These forms of muscular state support are designed to help domestic solar firms succeed in a glutted and low-profit global market by promoting productivity gains. Yet in struggling to navigate the forces of the climate crisis and the potential stagnation of solar PV, these state initiatives exacerbate another pole of the wicked trinity by undermining the potential of solar to act as a source of job creation. For instance, in the US in 2020, solar jobs declined by around 7 % while solar capacity installations increased to record heights (SEIA, 2021). Indeed, the US' largest solar plant – Copper Mountain Solar in Nevada – created just five permanent jobs (power-technology.com, 2015). The expulsion of labour through automation is also prominent in the mining activities that produce the materials used for solar PV. In addition to quartz, panels require mined metals such as copper and zinc, as well as by-products from the smelting of these metals, like cadmium and tellurium (Mulvaney, 2019). As Arboleda (2020: 20) describes in his account of the Chilean copper complex, minerals are extracted by '[a]utonomous trucks and shovels', before being transported by a 'semiautomated train' to be refined in 'computerized ovens' and finally shipped around the

world through mechanized ports. Indeed, the automation of the solar PV supply chain not only further contributes to overproduction and declining profitability in the aggregate, but also worsens the problem of surplus populations – rendering increasingly illusive the visions of a worker-friendly energy shift embedded in the concepts of the Green New Deal and Just Transition.

Finally, to further combat the profit-eroding effects of solar price deflation, labour-intensive portions of the solar supply chain have been dispersed to parts of the world where illiberal states oversee authoritarian labour regimes. Infamously, China's Xinjiang region now produces 45 % of the world's solar-grade silicon (Murphy and Elimä, 2021: 8). In Xinjiang, Uyghur and Kazakh people are compelled by the Chinese state, under threat of internment, to work in the solar industry for a pittance or for no pay at all (Murphy and Elimä, 2021). Similarly, US, European, South Korean, and Japanese solar panel manufacturers began to relocate their production to Malaysia in the 2010s (Bradsher, 2014). With its low wages and circumscribed labour rights, Malaysia boasted 11 % of global crystalline silicon and thin film panel production capacity by 2016 (Mulvaney, 2019: 28). In Europe too panel manufacturers are spinning their production off to their near periphery in search of cheaper and more pliant labour. In recent years, certain Swiss solar panel manufacturers have shifted their production to Hungary, where Victor Orbán self-described 'illiberal' government has introduced a raft of anti-worker legislation (Szóke, 2020).

States initially sparked the solar PV boom through effective subsidy regimes. Yet these political interventions were meant to spark a market revolution that would become self-propelling. In fact, the very engine of the solar miracle was also its undoing: fierce competition and productivity gains created cheaper solar panels, but also dwindling profitability. To rekindle solar PV's dynamism – critical to meeting decarbonization commitments – states are increasingly pressed to violate liberal governance orthodoxies, through the indefinite continuation of subsidies or support for automation technologies. Yet pursuing the latter strategy further expels workers from the industry, exacerbating the problem of labour superfluity. In segments of the solar supply chain that are difficult to automate, production is being gradually relocated to states with authoritarian labour regimes, as firms seek to maintain profitability despite glutted world markets. In governing solar PV, states remain trapped in the wicked trilemma of late capitalism – a challenge to which liberal policy frameworks appear to provide few solutions.

## 5. Conclusion

This article contributes to ongoing debates on state-led environmental transitions by offering a richer understanding of the tensions and contradictions underpinning the governance of late capitalism. Our analysis sheds light on the secular tendencies propelled by capitalism's directional development which are shaping the political ecological futures of the capitalist state: environmental breakdown, labour superfluity, and waning economic dynamism. In particular, we draw attention to the ways in which the intersecting crises of late capitalism generate new, irreconcilable dilemmas for capitalist states to manage. Indeed, even as capitalism's directional motion produces economic stagnation while shedding superfluous workers and intensifying environmental harm, society cannot afford to decelerate lest the economy is thrown into even deeper disarray. State managers are called to put out fires on multiple fronts, yet in practice tackling one of the trinity's crisis-poles without exacerbating another becomes an elusive goal. Increasingly exceptional, exclusionary, and authoritarian political interventions are needed both to keep capitalism's economic engine running and manage its associated socio-environmental emergencies. In short, the 'wicked trinity' has created an uncertain, crisis-prone and precarious social order that has become quasi-ungovernable by liberal means.

The case of the solar panel industry offers a crucial glimpse of the irreconcilable challenges that state-led green transitions are bound to

encounter in the age of the wicked trinity. Despite large government subsidies to the sector, the dynamism of the solar industry quickly gave way to thinning profitability and overproduction, while at the same time struggling to absorb significant employment shares. Underlying the impasses of the sector is a growing asymmetry between the sheer volume of liberal-defying measures mobilized by states and capitalism's feeble potential for transforming into an inclusive and green economy at this particular historical juncture.

Our analysis is sobering for the prospects of political initiatives that hope to harness capitalist growth for the purposes of decarbonization – whether market-based or Keynesian strategies (World Bank, 2012; Pollin, 2019). Waning economic dynamism poses major problems for proposals in the vein of the Green New Deal, insofar as they posit dynamic growth as the material basis for scaling up clean energy investment and creating employment. Furthermore, the multiplication of surplus populations raises doubt as to the capability of such plans to create job opportunities and raise living standard for the masses. The key challenge is indeed to absorb the growing labour superfluity produced by the directionality of capital, not simply the workers who will lose their jobs when fossil fuel industries close. Certain Green New Deal and degrowth approaches also presuppose an enlarged state role in new clean energy investment, in order to lower the demands for profitability in energy sectors and lengthen investment horizons (Pollin 2019; Schor and Jorgenson 2019). Setting aside the question of how states would mobilize the necessary resources over the long term to socialize investment (without undercutting each other), altering profitability requirements does not do away with the dynamics of overproduction fuelled by the capitalist compulsion to increase labour productivity highlighted in this article.

More promising are the radical elements that appear in some strands of Green New Deal and degrowth thinking – as well as eco-socialist and indigenous traditions – that advocate forms of common ownership and democratic control of energy resources (Mastini et al., 2021; Liegey and Nelson, 2020; Vettese and Pendergrass, 2022). Dismantling private ownership and market competition is after all the key to defusing the interlocking disasters of the wicked trinity. Such initiatives would require tremendous social struggle, whether they seek to instrumentalize the state to transform property relations or construct alternative forms of communal life beyond the state. Indeed, a core strategic question that arises from our analysis is how radical climate movements should relate to states whose liberal features are vanishing as they strain to reproduce the bases of capitalist civilization in the face of the intersecting crises of economy, work, and nature. Strategies by environmental justice movements to seize political power must negotiate the challenge of states' increasingly authoritarian and undemocratic character. But so too must strategies that foreground localized, sustainable modes of living – they could face the dilemma of expanding to the point that they invoke illiberal state repression or remaining small sustainable islands in a sea of capitalist relations.

The purpose of our analysis is to reveal the structuring conditions in which social struggles must take place. While the directional transformation of capitalism and the attendant warping of the liberal state present great challenges to emancipatory social movements, they also create openings. Importantly, the anachronism of liberal governance points to the possibility and necessity of building alternative political institutions that would allow society to consciously regulate social life instead of remaining subject to the imperatives of value production. By deploying discretionary, liberal-defying, and market-distorting measures, states inadvertently open up the space for the politicization of economic relations in more emancipatory directions. In other words, the secular crisis of liberal governance offers a glimpse of a society whose hands are not tied by the deadlocks of the capitalist market. The existential crises we face compel us to push for the transcendence of the liberal form of the state and the transformation of the latter 'from an organ superimposed upon society into one completely subordinate to it' (Marx, 2019: 1038).

## Funding details

This article is part of a project that has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 101024448.

## Authors contributions

All authors have contributed equally to conceptualization, investigation, writing (original draft, reviewing, and editing), visualization, and project administration.

## 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.

## Data availability

Data will be made available on request.

## Acknowledgments

Thanks are due to Mat Paterson, Brett Christophers, Javier Moreno-Zacares, Nick Bernards, Gabe Eckhouse, Jevgeniy Bluwstein, and two anonymous reviewers for their generous feedback.

## References

- Alami, I., Dixon, A.D., 2022. "Expropriation of Capitalist by State Capitalist": Organizational Change and the Centralization of Capital as State Property. *Econ. Geogr.* 98 (4), 303–326.
- Alami, I., Dixon, A.D., 2023. Uneven and combined state capitalism. *EPA: Economy Space* 55 (1), 72–99.
- Altwater, E., 2007. The social and natural environment of fossil capitalism. *Socialist Register* 43, 39–59.
- Angel, J., 2017. Towards an energy politics in-against-and- beyond the state: Berlin's struggle for energy democracy. *Antipode* 49 (3), 557–576.
- Angel, J., Loftus, A., 2019. With-against-and-beyond the human right to water. *Geoforum* 98, 206–213.
- Arboleda, M., 2020. Planetary Mine: Territories of Extraction Under Late Capitalism. Verso, London.
- Aronoff, K., et al., 2019. A Planet to Win: Why We Need a Green New Deal. Verso, London.
- Arzuaga, F., 2019. Socially necessary superfluity: Adorno and Marx on the crises of labor and the individual. *Philos. Soc. Crit.* 45 (7), 819–843.
- Bellamy Foster, J., 1992. The absolute general law of environmental degradation under capitalism. *Capital. Nat. Social.* 3 (3), 77–81.
- Benanav, A., 2020. Automation and the Future of Work. Verso, London.
- Bernards, N., Soederberg, S., 2021. Relative surplus populations and the crises of contemporary capitalism: Reviving, revisiting, recasting. *Geoforum* 126, 412–419.
- Best, J., 2017. Security, economy, population: The political economic logic of liberal exceptionalism. *Secur. Dialogue* 48 (5), 375–392.
- Bistline, J., 2017. Economic and technical challenges of flexible operations under large-scale variable renewable deployment. *Energy Econ.* 64, 363–372.
- BloombergNEF, 2019. Clean energy investment exceeded \$300 billion once again in 2018. Available from: <https://about.bnef.com/blog/clean-energy-investment-exceeded-300-billion-2018/>.
- Blumenfeld, J., 2022. Climate barbarism: Adapting to a wrong world. *Constellations*. <https://doi.org/10.1111/1467-8675.12596>.
- Blume-Werry, E., et al., 2021. Value Factors, Capture Prices and Cannibalism: nightmares for renewable energy decision-makers. *J. World Energy Law Business* 14 (4), 231–247.
- Bonefeld, W., 2010. Free economy and the strong state: Some notes on the state. *Cap. Class* 34 (1), 15–24.
- Bonefeld, W., 2014. *Critical Theory and the Critique of Political Economy: On Subversion and Negative Reason*. Bloomsbury, London.
- Bonefeld, W., 2020. Capital par excellence: on money as an obscure thing. *Estudios de Filosofia* 62, 33–56.
- Bradsher, K., 2014. Solar rises in Malaysia during trade wars over panels. *New York Times*, December 11. Available from: <https://www.nytimes.com/2014/12/12/business/energy-environment/solar-rises-in-malaysia-during-trade-wars-over-panels.html>.
- Brand, U., Wissen, M., 2021. *The imperial mode of living: Everyday life and the ecological crisis of capitalism*. Verso Books.
- Brand, U., Görg, C., Wissen, M., 2011. Second-Order Condensations of Societal Power Relations: Environmental Politics and the Internationalization of the State from a Neo-Poulantzian Perspective 1. *Antipode* 43 (1), 149–175.
- Brenner, R., 2006. *The Economics of Global Turbulence: the advanced capitalist economies from long boom to long downturn, 1945-2005*. Verso, London.
- Bridge, G., 2014. Resource geographies II: The resource-state nexus. *Prog. Hum. Geogr.* 38 (1), 118–130.
- Brown, W., 2016. Sacrificial citizenship: Neoliberalism, human capital, and austerity politics. *Constellations* 23 (1), 3–14.
- Bruff, I., Tansel, C.B. (Eds.), 2020. *Authoritarian Neoliberalism: Philosophies, Practices, Contestations*. Routledge, London.
- Buch-Hansen, H., Carstensen, M.B., 2021. Paradigms and the political economy of ecopolitical projects: Green growth and degrowth compared. *Compet. Chang.* 25 (3–4), 308–327.
- Buonassisi, T. et al., 2016. How solar manufacturers can innovate in a high-capex, low-margin environment. *Greentechmedia.com*, May 24. Available from: <https://www.greentechmedia.com/articles/read/solar-capex>.
- Bulfone, F., 2023. Industrial policy and comparative political economy: a literature review and research agenda. *Compet. Change* 27 (1), 22–43.
- Burkett, P., 1999. *Marx and Nature: A Red and Green Perspective*. St. Martin's Press, New York.
- Burnham, P., 2011. Towards a political theory of crisis: Policy and resistance across Europe. *New Polit. Sci.* 33 (4), 493–507.
- Carchedi, G., Roberts, M. (Eds.), 2018. *World in crisis: A global analysis of Marx's law of profitability*. Haymarket Books, New York.
- Cassegard, C., 2021. *Toward a critical theory of nature: Capital, ecology, and dialectics*. Bloomsbury, New York.
- Castree, N., 2008. Neoliberalising nature: the logics of deregulation and reregulation. *Environ Plan A* 40 (1), 131–152.
- Causa, O., Abendschein, M., Luu, N., Soldani, E., Soriolo, C., 2022. The Post-COVID-19 Rise in Labour Shortages. *OECD Economics Department Working Papers*, No. 1721.
- Choonara, J., Murgia, A., Carmo, R., 2022. Afterword: A Pandemic of Precarity. In: Choonara, J., Murgia, A., Carmo, R. (Eds.), *Faces of Precarity: Critical Perspectives on Work, Subjectivities and Struggles*. Bristol University Press, Bristol, pp. 239–248.
- Christophers, B., 2021. Fossilised capital: Price and profit in the energy transition. *New Polit. Econ.* 27 (1), 146–159.
- Christophers, B., 2022. Taking renewables to market: Prospects for the after-subsidy energy transition. *Antipode*. <https://doi.org/10.1111/anti.12847>.
- Clarke, S., 1988. Keynesianism, monetarism and the crisis of the state. Edward Elgar, Aldershot.
- Clarke, S., 1994. *Marx's Theory of Crisis*. Palgrave Macmillan, Basingstoke.
- Clover, J., 2019. *Riot. Strike. Riot*. Verso, London.
- Copley, J., 2022. Decarbonizing the downturn: Addressing climate change in an age of stagnation. *Compet. Chang.* 10245294221120986.
- Copley, J., Moraitis, A., 2021. Beyond the mutual constitution of states and markets: On the governance of alienation. *New Polit. Econ.* 26 (3), 490–508.
- Craig, M.P., 2020. 'Treasury Control' and the British environmental state: The political economy of green development strategy in UK central government. *New Polit. Econ.* 25 (1), 30–45.
- D'Alisa, G., Kallis, G., 2020. Degrowth and the State. *Ecol. Econ.* 169 (March 2019), 106486.
- Davidson, S., 2012. The insuperable imperative: a critique of the ecologically modernizing state. *Capital. Nat. Social.* 23 (2), 31–50.
- Davies, W., 2013. When is a market not a market? 'Exemption', 'externality' and 'exception' in the case of European state aid rules. *Theory Cult. Soc.* 30 (2), 32–59.
- de Brunhoff, S., 1978. *The state, capital and economic policy*. Pluto Press, London.
- Death, C., 2016. *The green state in Africa*. Yale University Press.
- Dong, H., Zeng, B., Wang, Y., Liu, Y., Zeng, M., 2020. China's solar subsidy policy: Government funding yield to open markets. *IEEE Power Energy Mag.* 20 (3), 49–60.
- Douglas, R.M., 2020. The 'glass ceiling' of the environmental state and the social denial of mortality. *Environ. Polit.* 29 (1), 58–75.
- Dryzek, J.S., Downes, D., Hunold, C., Schlosberg, D., Hernes, H.K., 2003. *Green states and social movements: environmentalism in the United States, United Kingdom, OUP Oxford, Germany, and Norway*.
- Duit, A., Feindt, P.H., Meadowcroft, J., 2016. Greening Leviathan: the rise of the environmental state? *Environ. Polit.* 25 (1), 1–23.
- Eckersley, R., 2004. *The green state: rethinking democracy and sovereignty*. MIT Press.
- Eckersley, R., 2021. Greening states and societies: from transitions to great transformations. *Environ. Polit.* 30 (1–2), 245–265.
- Ekers, M., Loftus, A., Mann, G., 2009. Gramsci lives! *Geoforum* 40 (3), 287–291.
- Endnotes, 2010. 'Misery and Debt: On the Logic and History of Surplus Populations and Surplus Capital', *Endnotes*, 2, available at: <http://endnotes.org.uk/articles/1>.
- European Commission, 2021. Automated photovoltaic cell and module industrial production to regain and secure European renewable energy market. Available from: <https://cordis.europa.eu/project/id/745601>.
- Frankfurt School-UNEP Centre/BNEF, 2020. *Global Trends in Renewable Energy Investment 2020*. Available from: [https://www.fs-unep-centre.org/wp-content/uploads/2020/06/GTR\\_2020.pdf](https://www.fs-unep-centre.org/wp-content/uploads/2020/06/GTR_2020.pdf).
- Friedlingstein, P., et al., 2021. Global Carbon Budget 2021. *Earth Syst. Sci. Data*. <https://doi.org/10.5194/essd-2021-386>.
- Gilmore, R.W., 2007. *Golden Gulag: Prisons, Surplus, Crisis, and Opposition in Globalizing California*. University of California Press, Berkeley.
- Harris, L.M., 2017. Political ecologies of the state: Recent interventions and questions going forward. *Polit. Geogr.* 58, 90–92.

- Hart, D., 2020. The Impact of China's Production Surge on Innovation in the Global Solar Photovoltaics Industry. Information Technology and Innovation Foundation, Washington, D.C.
- Hausknost, D., Hammond, M., 2020. Beyond the environmental state? The political prospects of a sustainability transformation. *Environ. Polit.* 29 (1), 1–16.
- Hopkins, M., Li, Y., 2016. The rise of the Chinese solar photovoltaic industry. In: Zhou, Y., Lazonick, W., Sun, Y. (Eds.), *China as an Innovation Nation*. Oxford University Press, Oxford, pp. 306–332.
- Hoppmann, J., et al., 2014. Compulsive policy-making—The evolution of the German feed-in tariff system for solar photovoltaic power. *Res. Policy* 43 (8), 1422–1441.
- Hornborg, A., 2012. *Global ecology and unequal exchange: fetishism in a zero-sum world*. Routledge.
- Hunter, R., 2021. Capitalism, depoliticization, and climate politics. *Sci. Soc.* 85 (2), 184–191.
- IEA PVPS, 2021. Trends in Photovoltaic Applications. International Energy Agency, Photovoltaic Power Systems Programme. Available from: <https://tecsol.blogs.com/files/iea-pvps-trends-report-2021-1.pdf>.
- IRENA, 2020. Renewable Power Generation Costs in 2019. International Renewable Energy Agency, Abu Dhabi.
- Jappe, A., 2017. *La Société Autophage: Capitalisme, Démesure et Autodestruction*. La Découverte, Paris.
- Jones, P., 2021. *Work without the worker*. Verso, London.
- Koch, M., 2020. The state in the transformation to a sustainable postgrowth economy. *Environ. Polit.* 29 (1), 115–133.
- Kotz, D.M., 2015. *The Rise and Fall of Neoliberal Capitalism*. Harvard University Press, Cambridge, MA.
- Landa, I., 2010. *The Apprentice's Sorcerer*. Haymarket, Chicago.
- Lewis, M., 2020. Renewables bring deflation to the energy sector. *Financial Times*. <http://www.ft.com/content/f2a27ddb-ea88-46cc-a265-e84bd50946b>.
- Liegey, V., Nelson, A., 2020. Exploring Degrowth: A Critical Guide. Pluto, London.
- Loftus, A., 2020. Political ecology II: Whither the state? *Prog. Hum. Geogr.* 44 (1), 139–149. <https://doi.org/10.1177/0309132518803421>.
- Losurdo, D., 2011. *Liberalism: A counter-history*. Verso, London.
- Machado, N.M.C., 2021. The ecological limit of capitalism: Value-form and the accelerated destruction of nature in light of the theories of Karl Marx and Moishe Postone. In: Pejnovic, V.S. (Ed.), *Beyond Capitalism and Neoliberalism*. Institute for Political Studies, Belgrade, pp. 111–122.
- Malm, A., 2016. *Fossil Capital: The Rise of Steam Power and the Roots of Global Warming*. Verso, London.
- Malm, A., 2020. *How to Blow Up a Pipeline*. Verso, London.
- Mann, G., 2017. *In the long run we are all dead*. Verso, London.
- Mann, G., Wainwright, J., 2018. *Climate Leviathan: A political theory of our planetary future*. Verso, London.
- Marx, K., 1976. *Capital*, volume I. Penguin, London.
- Marx, K., 2019. *The Political Writings*. Verso, London.
- Mastini, R., Kallis, G., Hickel, J., 2021. A green new deal without growth? *Ecol. Econ.* 179, 106832.
- Meadowcroft, J., 2005. From welfare state to ecostate. In: Barry, J., Eckersley, R. (Eds.), *The State and the Global Ecological Crisis*. MIT Press, pp. 3–23.
- Meehan, K., Molden, O.C., 2015. Political ecologies of the state. In: Agnew, J. A., Mamadouh, V., Secor, A., Sharp, J. (Eds.), (2017). *The Wiley Blackwell companion to political geography*. John Wiley & Sons, 438–450.
- MIT Energy Initiative, 2015. *The Future of Solar Energy: An Interdisciplinary MIT Study*. MIT Energy Initiative, Cambridge.
- Mol, A., Spaargaren, G., 2000. Ecological Modernisation Theory in debate: A review. *Environ. Polit.* 9 (1), 17–49.
- Moraitis, A., 2022. From the post-industrial prophecy to the de-industrial nightmare: Stagnation, the manufacturing fetish and the limits of capitalist wealth. *Compet. Chang.* 26 (5), 513–532.
- Moraitis, A., 2021. *Secular Immiseration: Stagnation, Decline Management and the Limits of Capitalist Wealth*. University of Manchester.
- Müller, T., 2021. Blow up pipelines? Tadzio Müller and Andreas Malm on what next for the climate movement. *Dissens Podcast*, May 5. Available from: <https://podcast.dissenspodcast.de/123-climate>.
- Mulvaney, D., 2019. *Solar Power: Innovation, Sustainability, and Environmental Justice*. University of California Press, Oakland.
- Murphy, L., Elimä, N., 2021. In *Broad Daylight: Uyghur Forced Labour and Global Supply Chains*. Sheffield Hallam University, Sheffield.
- Nemet, G.F., 2019. *How Solar Energy Became Cheap: A Model for Low-Carbon Innovation*. Routledge, London.
- Newell, P., 2021. *Power shift: The global political economy of energy transitions*. Cambridge University Press.
- Ortlieb, C.P., 2013. A Contradiction Between Matter and Form: On the Significance of the Production of Relative Surplus Value in the Dynamic of Terminal Crisis. *Mediations* 27, 1–2.
- Parenti, C., 2015. The 2013 ANTIPODE AAG lecture the environment making state: Territory, nature, and value. *Antipode* 47 (4), 829–848.
- Paterson, M., 1996. *Global warming and global politics*. Routledge, London.
- Paterson, M., 2016. Political Economy of the Greening of the State. In: Gabrielson, T., Hall, C., Meyer, J.M., Schlosberg, D. (Eds.), *The Oxford handbook of environmental political theory*. Oxford University Press, pp. 1–17.
- Paterson, M., 2021. Climate change and international political economy: Between collapse and transformation. *Rev. Int. Polit. Econ.* 28 (2), 394–405.
- Pichler, M., Brand, U., Görg, C., 2020. The double materiality of democracy in capitalist societies: challenges for social-ecological transformations. *Environ. Polit.* 29 (2), 193–213.
- Pichler, M., Ingalls, M., 2021. Negotiating between forest conversion, industrial tree plantations and multifunctional landscapes. *Power and politics in forest transitions*. *Geoforum* 124, 185–194.
- Pickeler, K., 2022. America COMPETES Act of 2022 authorizes \$3 billion for domestic solar manufacturing. *Solar Power World*, January 26. Available from: <https://www.solarpowerworldonline.com/2022/01/america-competes-act-of-2022-authorizes-3-billion-for-domestic-solar-manufacturing/>.
- Plant, R., 2010. *The Neo-Liberal state*. Oxford University Press, Oxford.
- Platzer, M., 2015. *U.S. Solar Photovoltaic Manufacturing: Industry Trends, Global Competition, Federal Support*. Congressional Research Service, Washington, D.C.. Available from: <https://sgp.fas.org/crs/misc/R42509.pdf>.
- Pollin, R., 2019. Advancing a viable global climate stabilization project: Degrowth versus the green new deal. *Rev. Radical Polit. Econ.* 51 (2), 311–319.
- Powell, D., et al., 2015. The capital intensity of photovoltaics manufacturing: barrier to scale and opportunity for innovation. *Energy Environ. Sci.* 8, 3395–3408.
- Power-technology.com, 2015. *Copper Mountain Solar 1*. Power-technology.com, December 30. Available from: <https://www.power-technology.com/projects/copper-mountain-solar-1/>.
- Proel, J.L., Steining, K.W., Zilberman, D., 2020. The cannibalization effect of wind and solar in the California wholesale electricity market. *Energy Econ.* 85, 1–15.
- PWC, 2016. *Seeing Through the Gloom: UK Solar Seeks Stability After Subsidy Cuts*. Available from: <https://www.pwc.co.uk/power-utilities/assets/solar-report-2016.pdf>.
- REGlobal, 2021. *European Union's solar power fleet will double by 2025: SolarPower Europe*. REGlobal, December 21. Available from: <https://reglobal.co/eu-solar-market-outlook-till-2025/>.
- REN21, 2017. *Renewables 2017 Global Status Report*. REN21 Secretariat, Paris.
- REN21, 2021. *Renewables 2021 Global Status Report*. REN21 Secretariat, Paris.
- Resquared.com (2021). *RE2 announces solar program with US Department of Energy*. Resquared.com, March 2. Available from: <https://www.resquared.com/blog/re2-doe-robot-for-solar-fields>.
- Robbins, P., 2008. The State in political ecology: a postcard to political geography from the field, in Cox, Low, Robinson. In: London, U.K. (Ed.), *Handbook of Political Geography*. Sage Publications, pp. 251–268.
- Robertson, M., 2015. Environmental Governance: Political Ecology and the State. In: Perreault, T., Bridge, G., McCarthy, J. (Eds.), *The Routledge Handbook of Political Ecology*. Routledge, pp. 457–466.
- Robertson, M.M., Wainwright, J.D., 2013. The Value of Nature to the State. *Ann. Assoc. Am. Geogr.* 103 (4), 890–905.
- Roser, M., Ortiz-Ospina, E., 2022. *Solar PV module prices*. *Our World In Data*. Available from: <https://ourworldindata.org/grapher/solar-pv-prices?time=2000.latest>.
- Rübner Hansen, B., 2021. *The Kaleidoscope of Catastrophe - On the Clarities and Blind Spots of Andreas Malm*. *Viewpoint Magazine*, 14 April. Available from: <https://viewpointmag.com/2021/04/14/the-kaleidoscope-of-catastrophe-on-the-clarities-and-blind-spots-of-andreas-malm/>.
- Sandalow, D., 2019. *2019 Guide to Chinese Climate Policy*. Columbia Center on Global Energy Policy, New York.
- Santacreu, A.M., LaBelle, J., 2022. *Global Supply Chain Disruptions and Inflation During the COVID-19 Pandemic*. Federal Reserve Bank of St. Louis. *Review*, Second Quarter 2022, 78–91. <https://doi.org/10.20955/r.104.78-91>.
- Schnaiberg, A., 1980. *The environment: From surplus to scarcity*. Oxford University Press, New York.
- Schor, J.B., Jorgenson, A.K., 2019. Is it too late for growth? *Rev. Radical Polit. Econ.* 51 (2), 320–329.
- Schwartz, H.M., 2021. *Global secular stagnation and the rise of intellectual property monopoly*. *Rev. Int. Polit. Econ.* 1–26.
- SEIA, 2021. *National Solar Jobs Census*. Available from: <https://www.seia.org/research-resources/national-solar-jobs-census-2020>.
- Sendstad, L., et al., 2022. The impact of subsidy retraction on European renewable energy investments. *Energy Policy* 160, no. 112675.
- Sivaram, V., Kann, S., 2016. Solar power needs a more ambitious cost target. *Nature Energy* 1 (16036).
- Smith, J.E., 2020. *Smart Machines and Service Work*. Reaktion Books, London.
- Šumonja, M., 2021. Neoliberalism is not dead—On political implications of Covid-19. *Cap. Class* 45 (2), 215–227.
- Szöke, E., 2020. *Swiss Flisom to produce light weight solar panels in Hungary*. *Ceenergynews*, April 29. Available from: <https://ceenergynews.com/climate/swiss-flisom-to-produce-lightweight-solar-panels-in-hungary/>.
- Transnational Institute, 2021. *Global Climate Wall: how the world's wealthiest nations prioritise borders over climate action*. Transnational Institute, Amsterdam. available at: <https://www.tni.org/en/publication/global-climate-wall>.
- UNEP, 2012. *Feed-in Tariffs as a Policy Instrument for Promoting Renewable Energies and Green Economics in Developing Countries*. Available from: <https://wedocs.unep.org/handle/20.500.11822/8102>.
- Tooze, A., 2018. *Crashed: How a decade of financial crises changed the world*. Penguin, London.
- Toscano, A., 2020. The state of the pandemic. *Hist. Mater.* 28 (4), 3–23.
- Vettese, T., Pendergrass, D., 2022. *Half-Earth Socialism: A Plan to Save the Future from Extinction, Climate Change, and Pandemics*. Verso, London.
- Wacquant, L., 2010. Crafting the neoliberal state: workfare, prisonfare and social insecurity. *Sociol. Forum* 25, 197–220.
- Weiss, H., 2021. Elusive adulthood and surplus life-time in Spain. *Crit. Anthropol.* 41 (2), 149–164.
- Whitehead, M., Jones, R., Jones, M., 2007. *The Nature of the State: Excavating the Political Ecologies of the Modern State*. Oxford University Press, Oxford.

WIPO, 2017. World Intellectual Property Report 2017: Intangible capital in global value chains. World Intellectual Property Organization, Geneva.

Wiser, R., Bolinger, M., Seel, J., 2020. Benchmarking utility-scale solar PV operational expenses and project lifetimes: Results from a survey of US solar industry professionals. Lawrence Berkeley National Laboratory, Berkeley. Available from: [https://eta-publications.lbl.gov/sites/default/files/solar\\_life\\_and\\_opex\\_report.pdf](https://eta-publications.lbl.gov/sites/default/files/solar_life_and_opex_report.pdf).

Wood, E.M., 1981. The separation of the economic and political in capitalism. *New Left Rev* 1 (127), 66–95.

World Bank, 2012. *Inclusive Green Growth: The Pathway to a Sustainable World*. World Bank, Washington, DC.